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Leyva, Jr. et al.

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(54) **FIBER OPTIC CONNECTOR INSTALLATION TOOL**

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(73) Assignee: **Corning Optical Communications LLC**, Hickory, NC (US)

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(51) **Int. Cl.**

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G02B 6/00	(2006.01)
G02B 6/38	(2006.01)
G01M 11/00	(2006.01)

(52) **U.S. Cl.**

CPC ***G02B 6/3898*** (2013.01); ***G01M 11/30*** (2013.01); ***G02B 6/3802*** (2013.01); ***G02B 6/385*** (2013.01); ***G02B 6/3826*** (2013.01); ***G02B 6/3846*** (2013.01); *G02B 6/3806* (2013.01); *G02B 6/3833* (2013.01); *G02B 6/3843* (2013.01)

(58) **Field of Classification Search**

CPC G02B 6/4454; G02B 6/3869; G02B 6/385; G02B 6/3846; G02B 6/3898; G02B 6/3802

USPC 385/76, 78, 87, 134, 135

See application file for complete search history.

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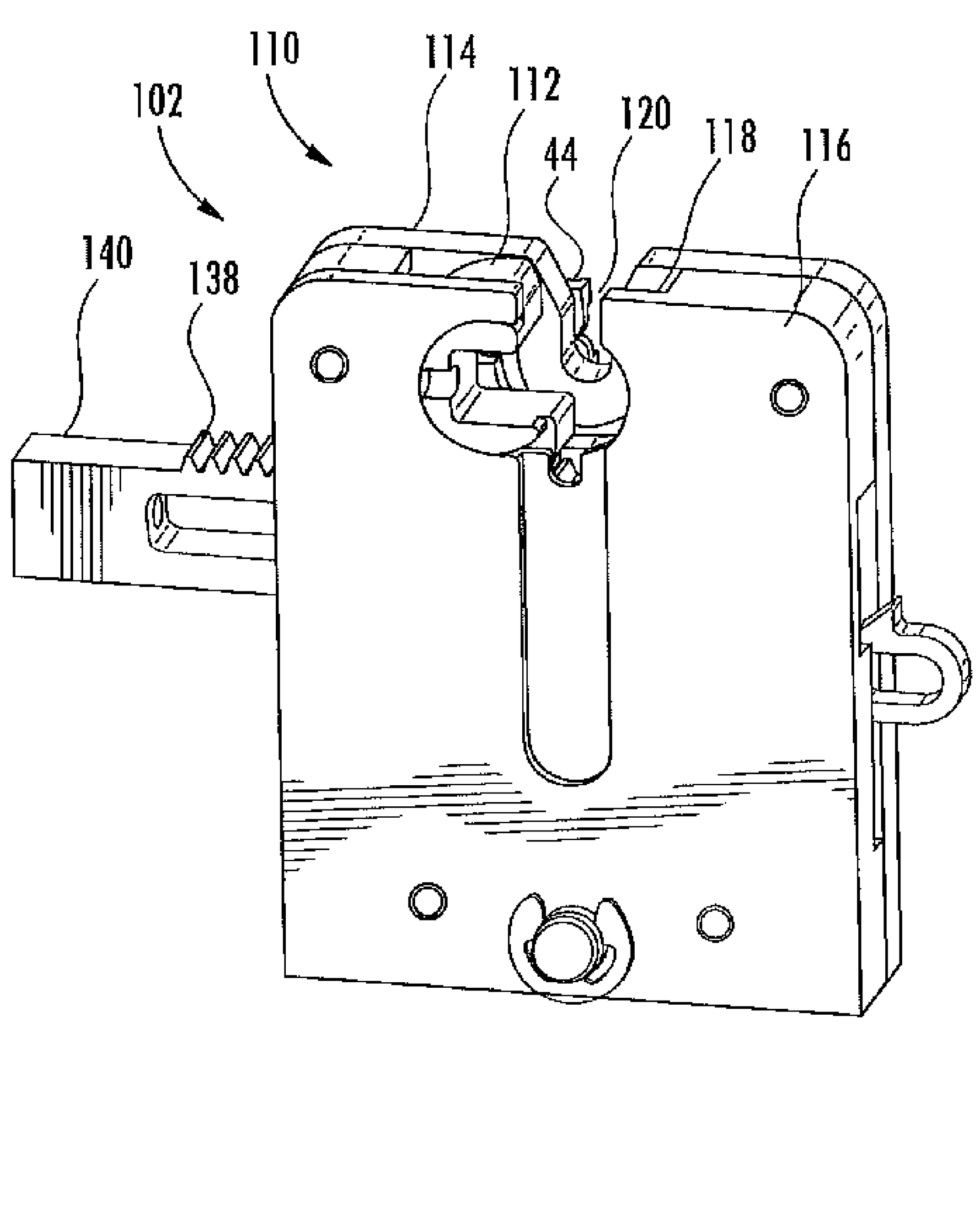
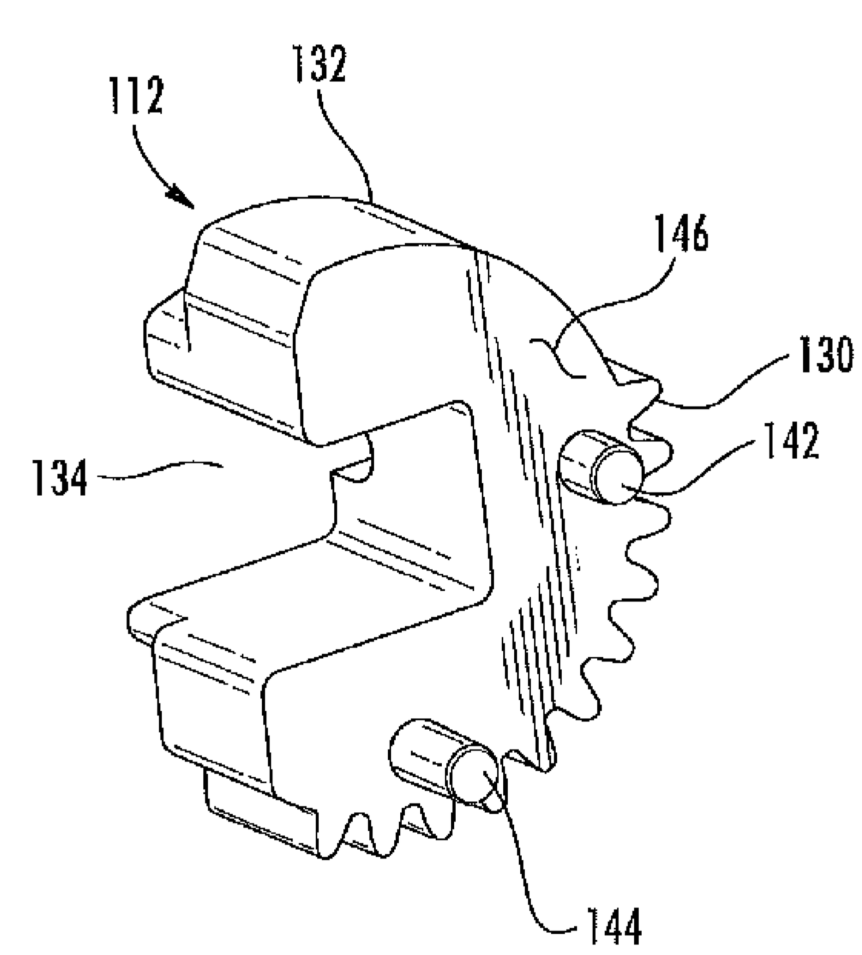
Primary Examiner — Kaveh C Kianni
Assistant Examiner — Hung Lam

(57) **ABSTRACT**

An installation tool for terminating one or more field optical fibers with a fiber optic connector includes a guide member and camming member. The guide member has a slot extending in an axial direction and is configured to receive a portion of the fiber optic connector. The camming member is positioned next to the guide member and is movable between a first position spaced from the slot and a second position axially aligned with the slot. Additionally, the camming member is configured to engage and actuate a cam member of the fiber optic connector by moving from the first position to the second position when the fiber optic connector is received in the slot.

18 Claims, 9 Drawing Sheets





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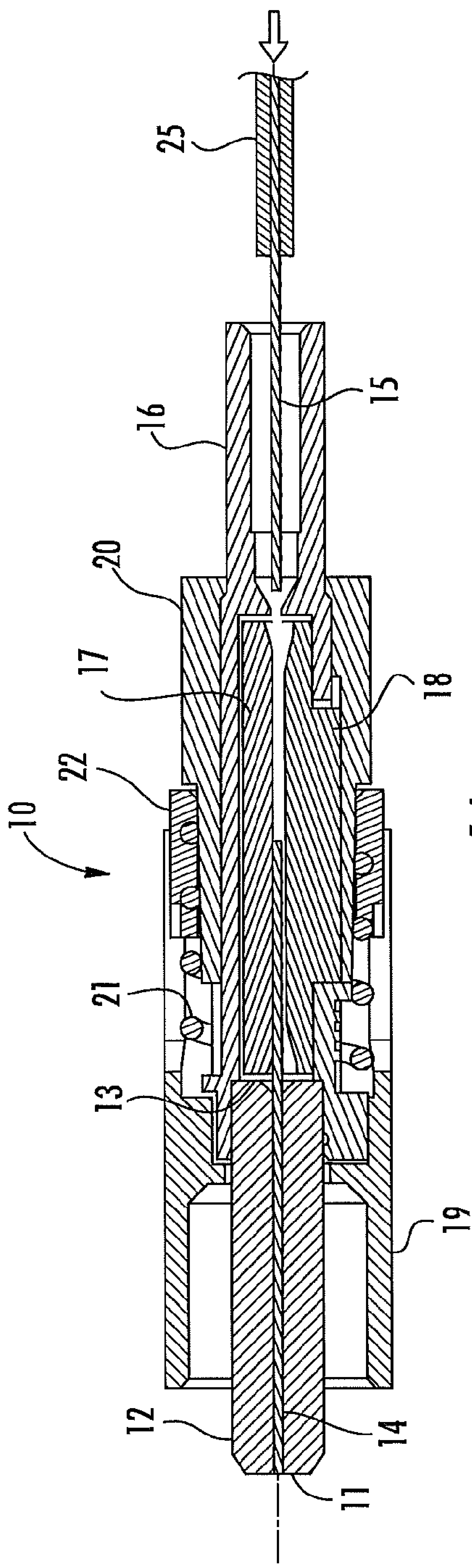
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FIG. 1A

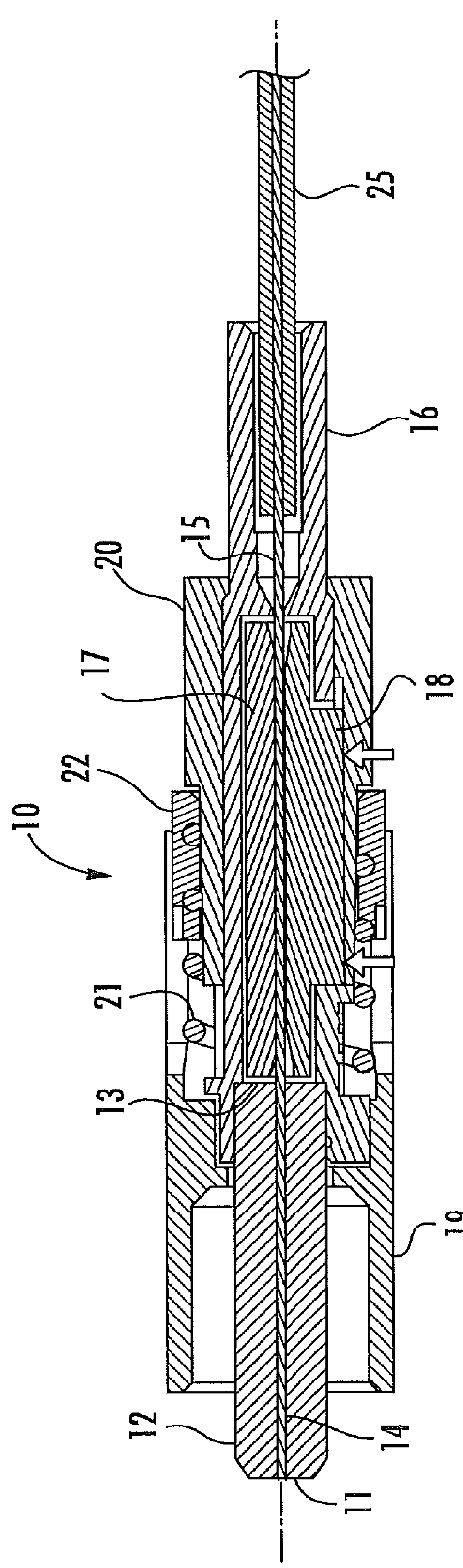
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FIG. 1B

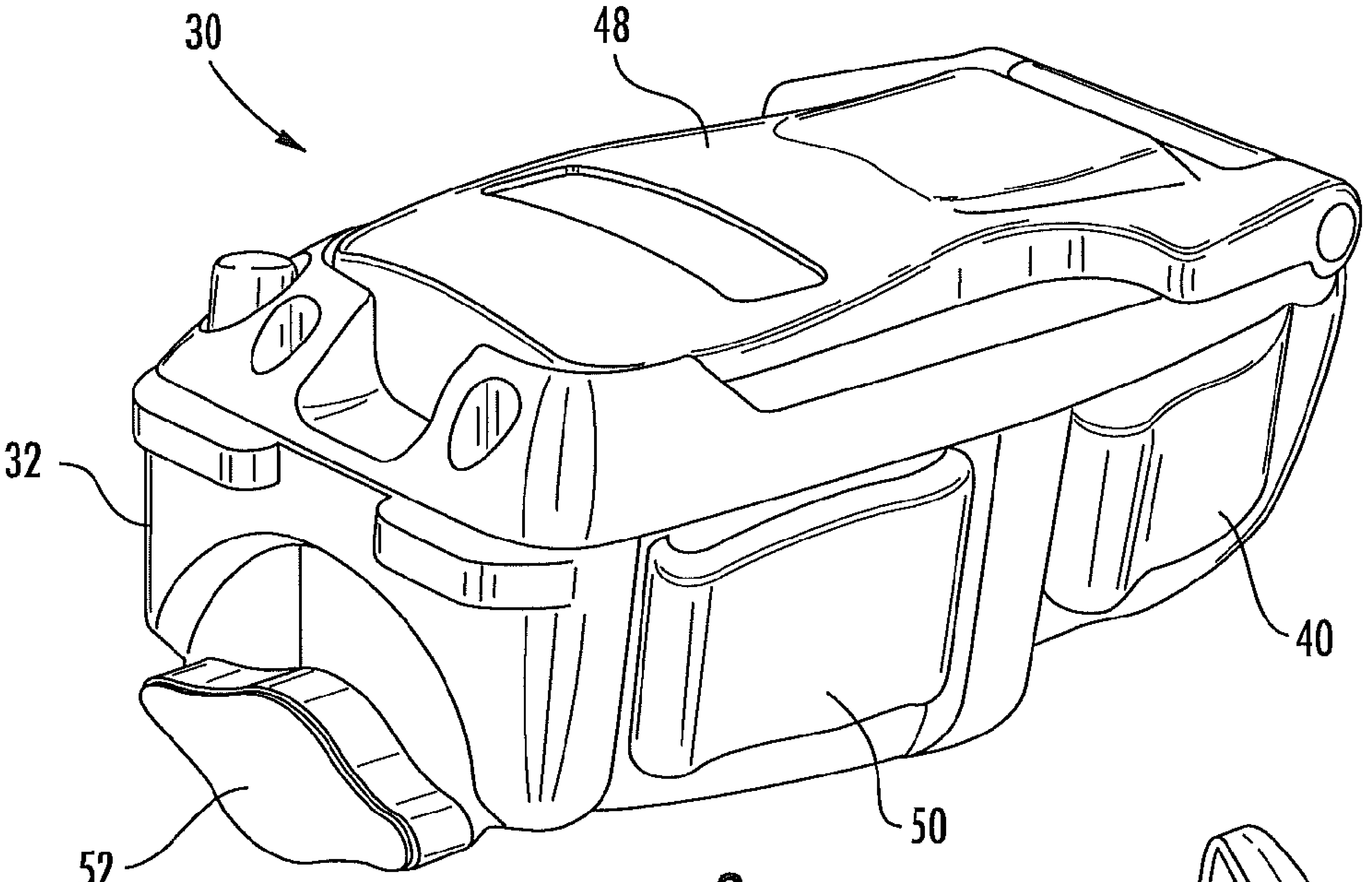

FIG. 2

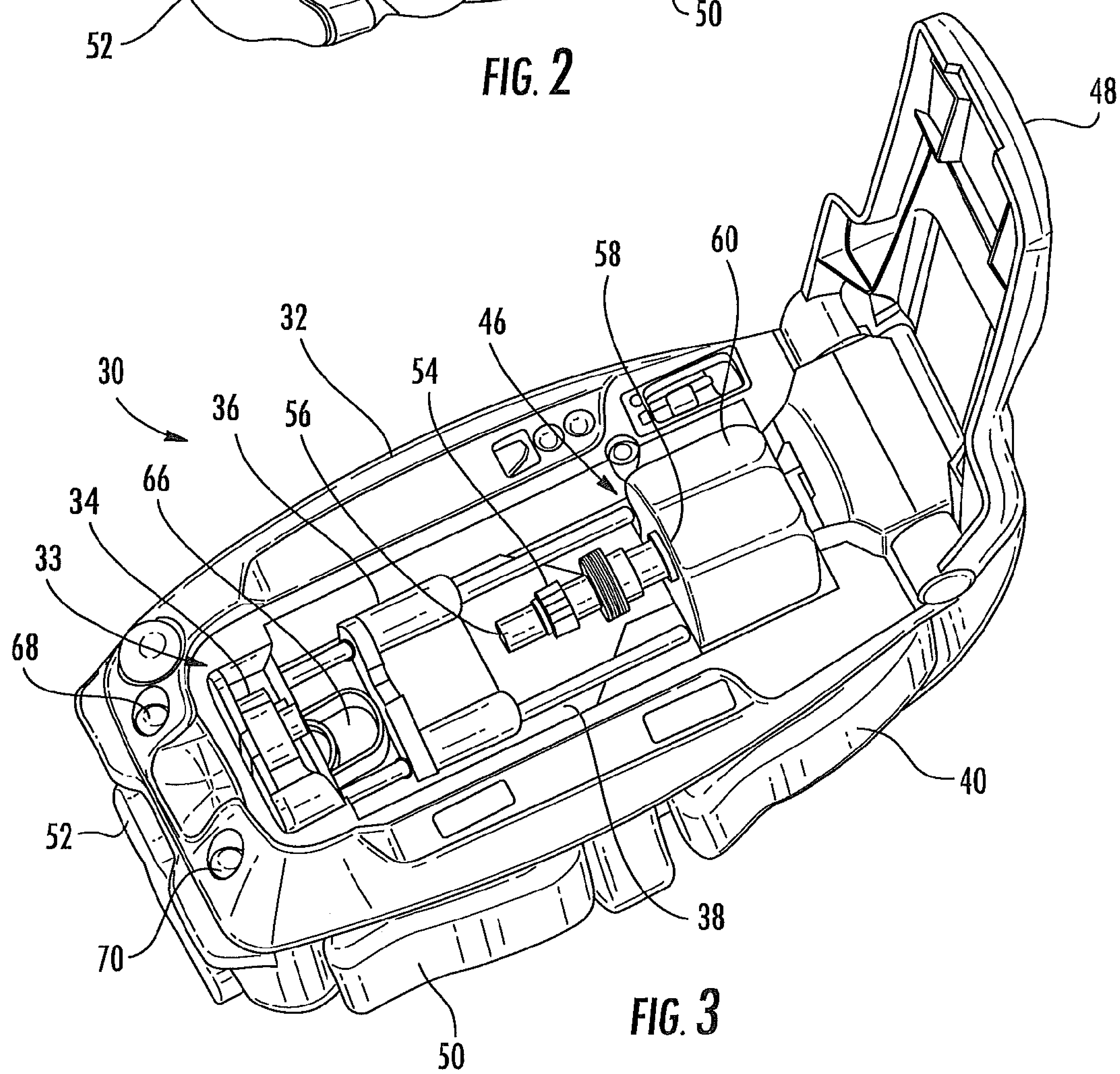

FIG. 3

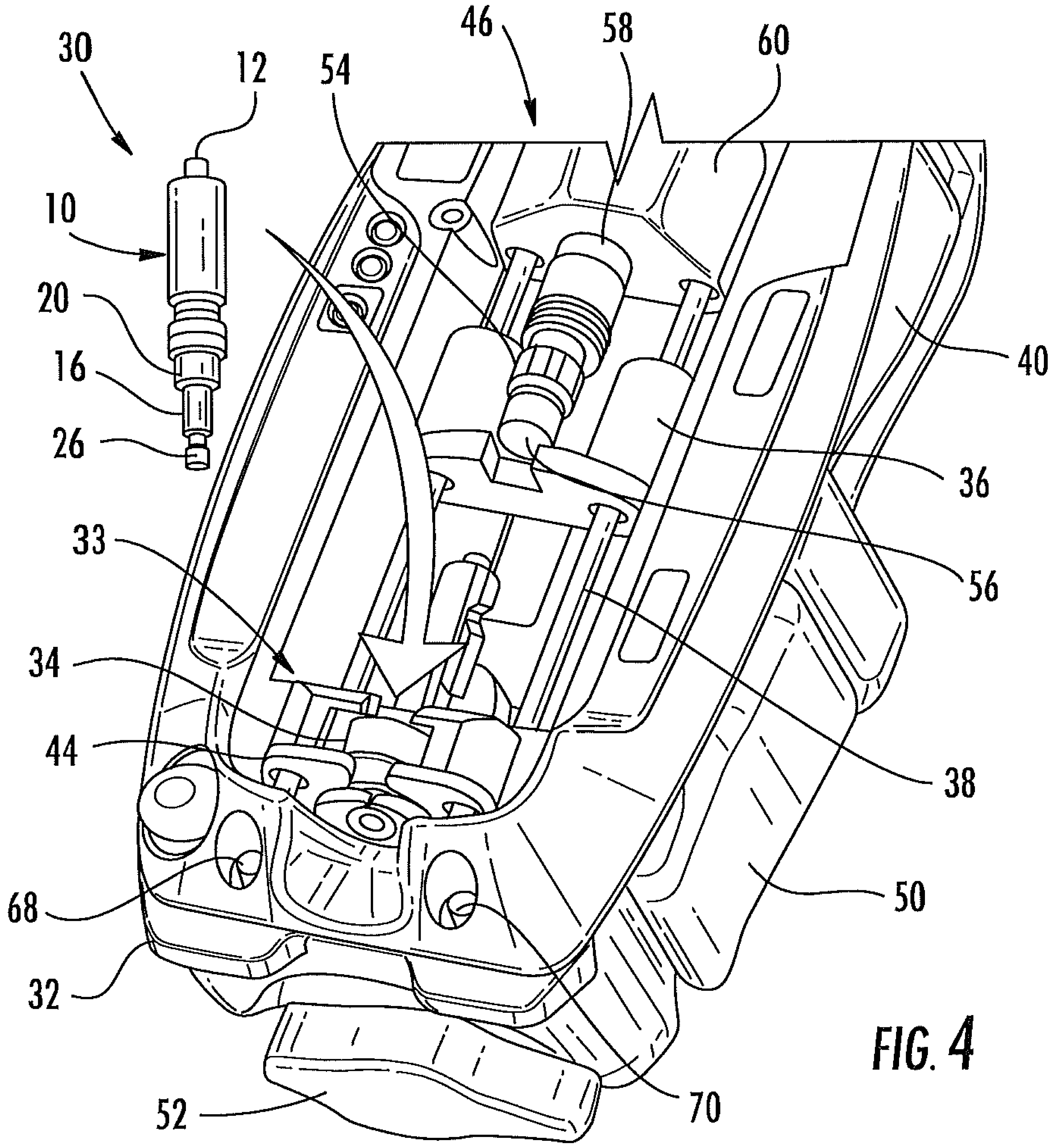

FIG. 4

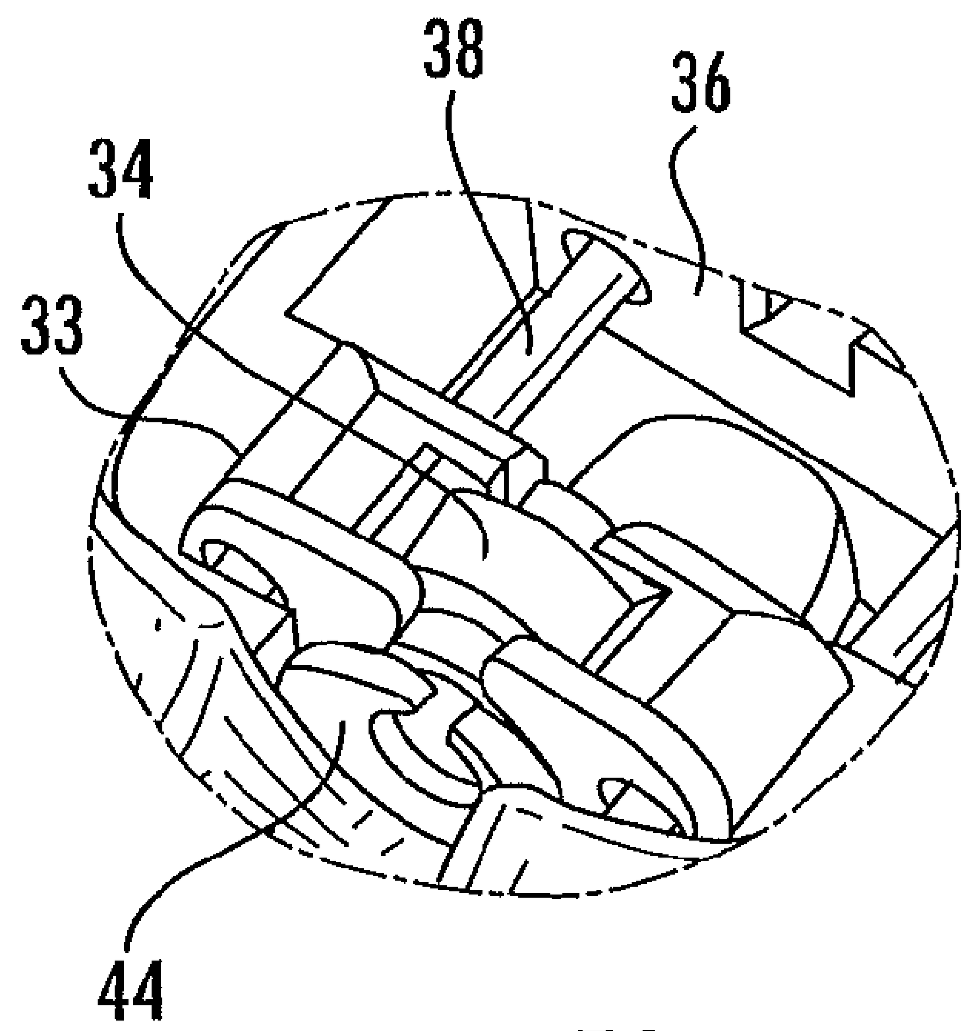

FIG. 5A

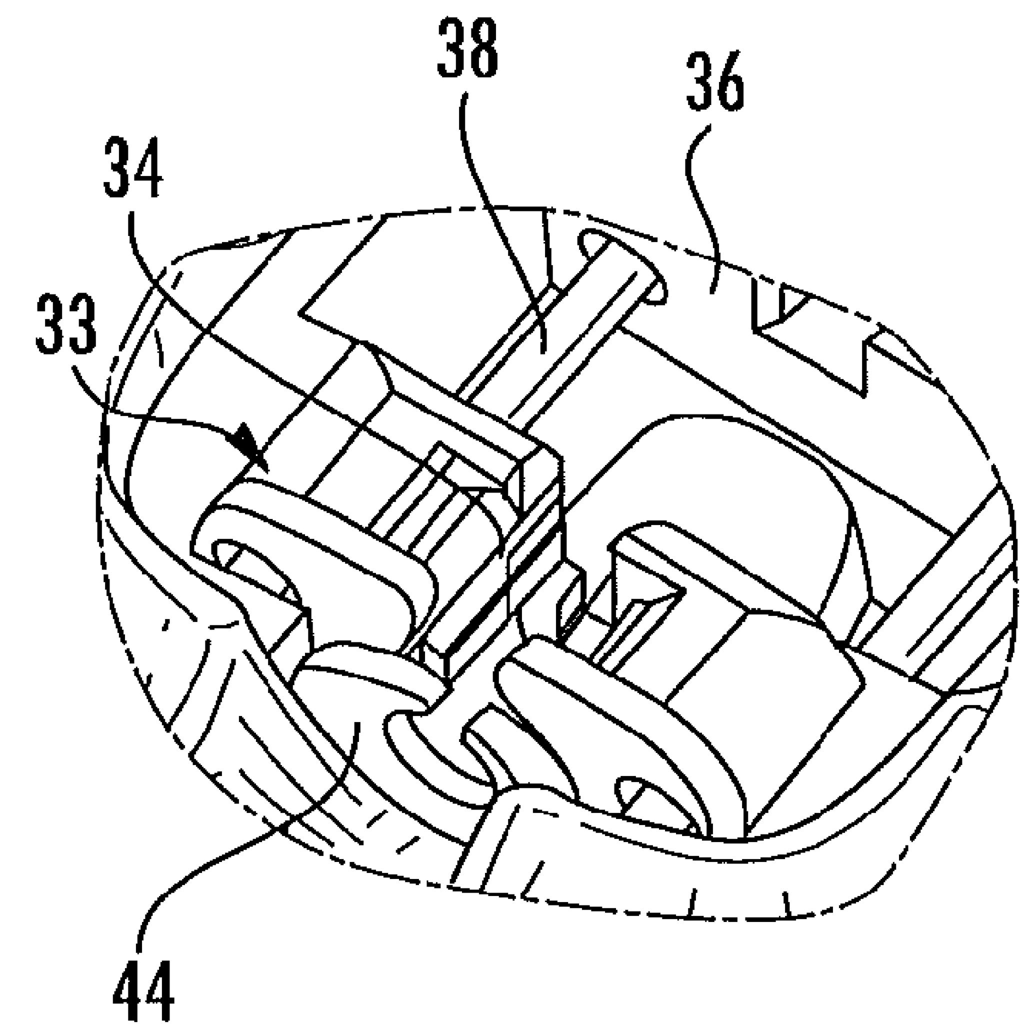

FIG. 5B

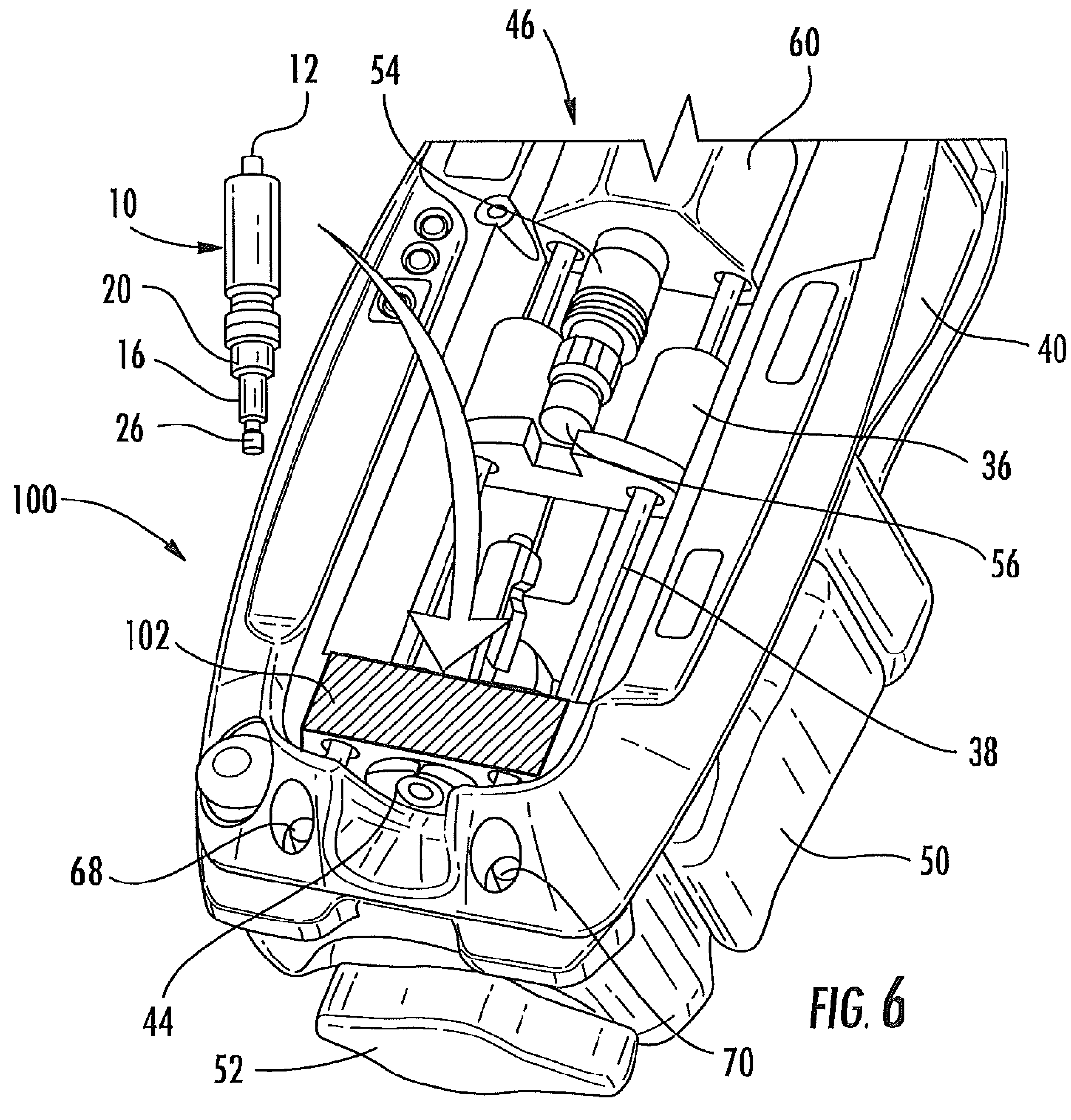

FIG. 6

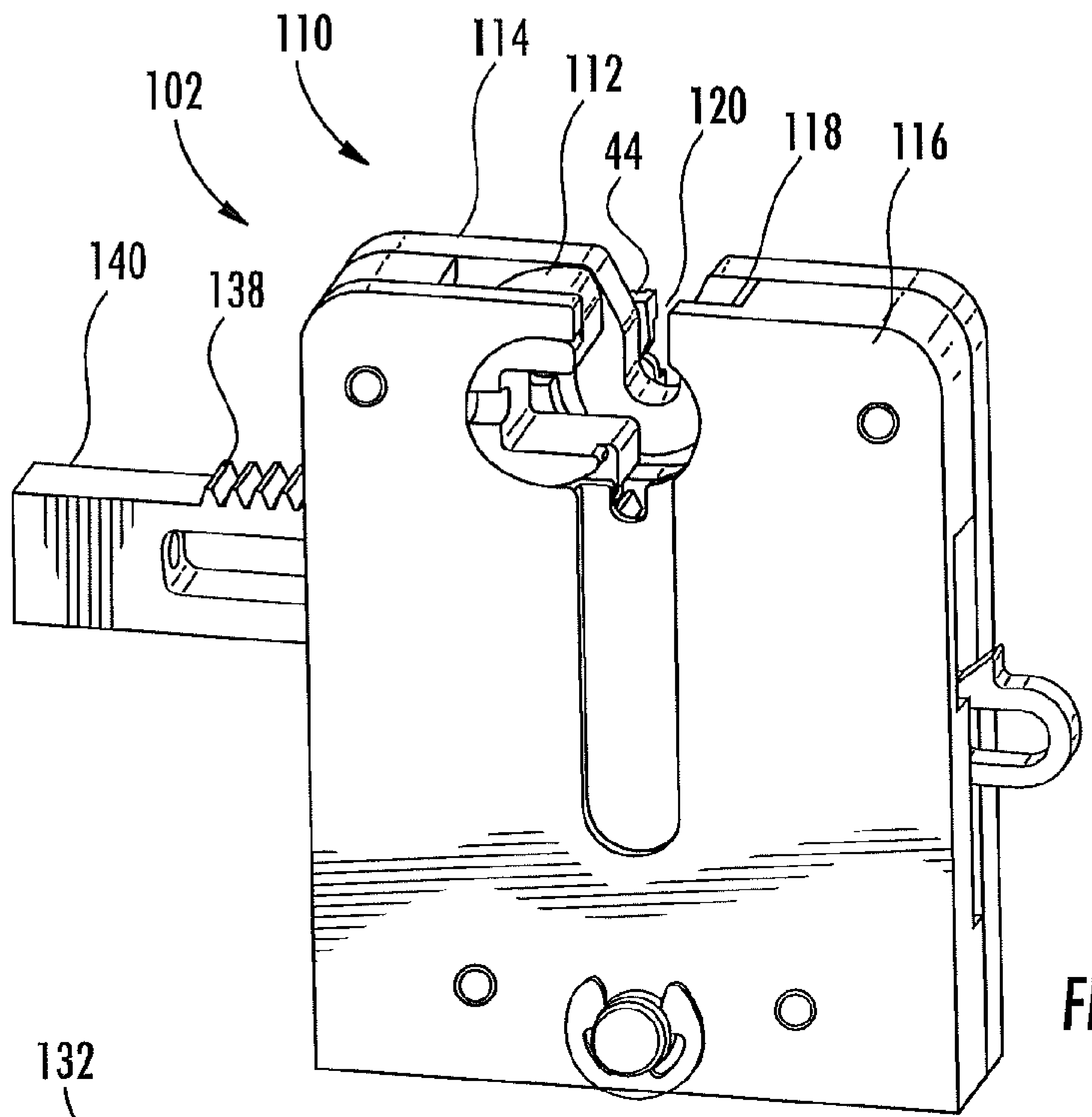

FIG. 7

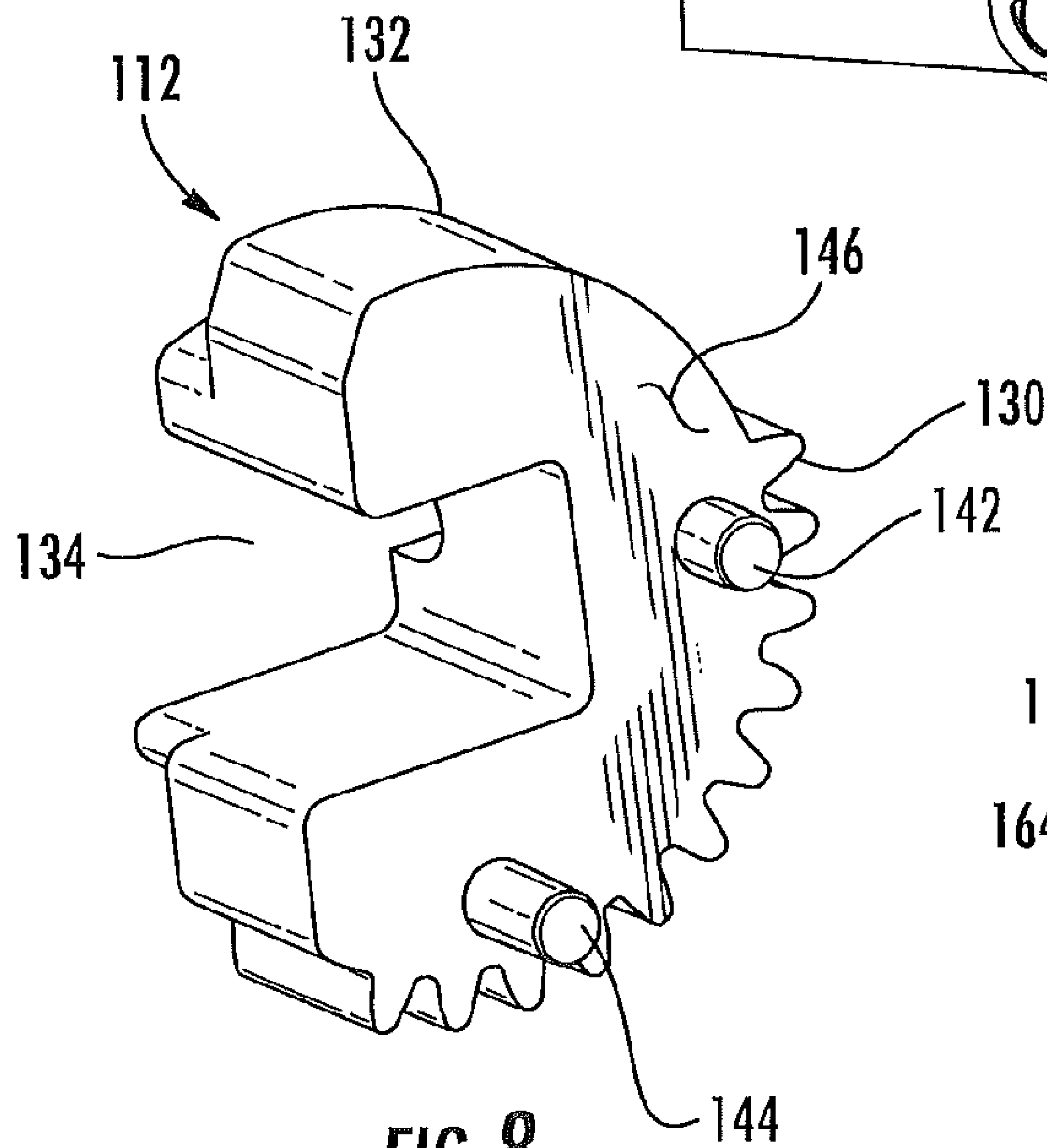

FIG. 8

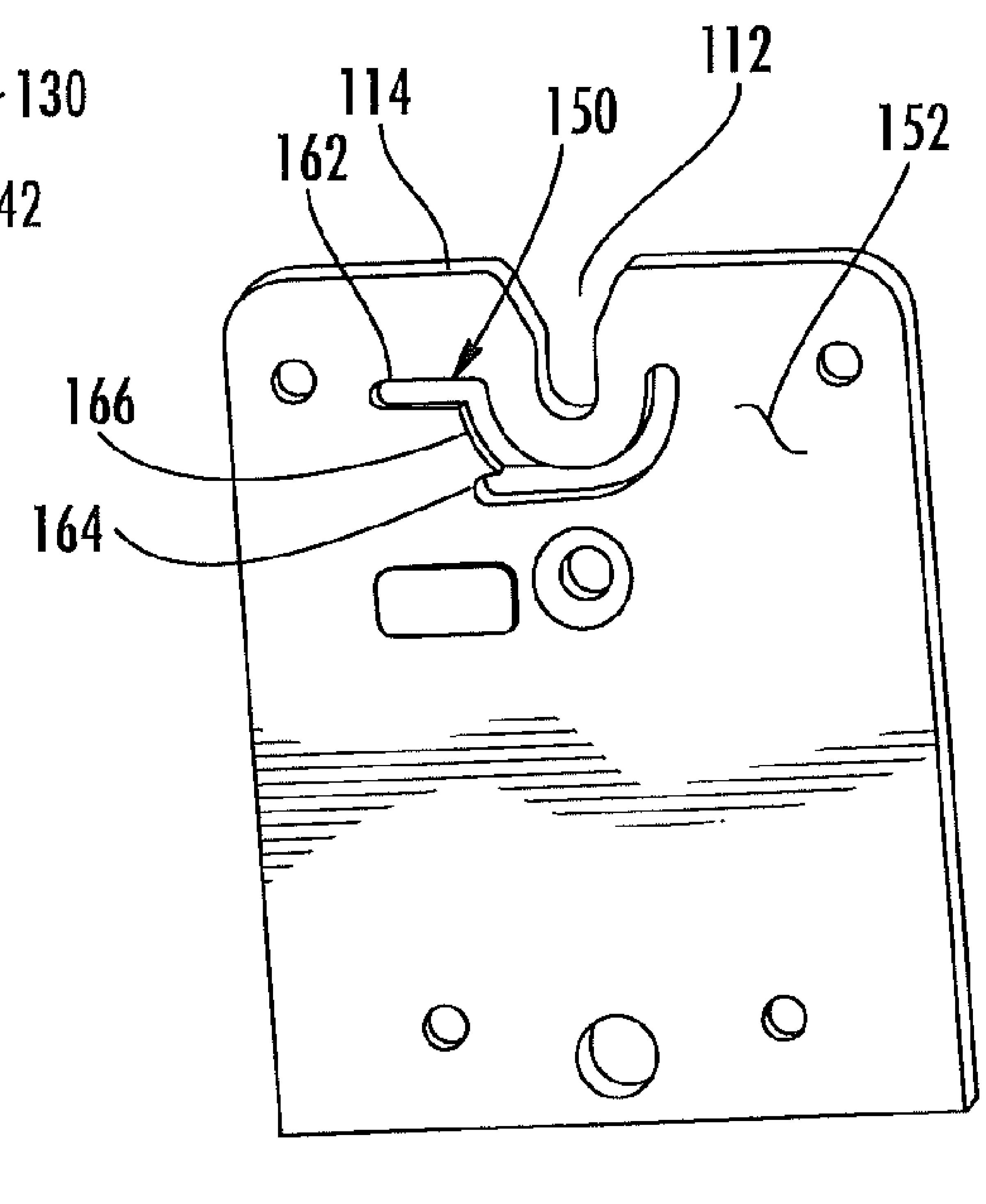

FIG. 9

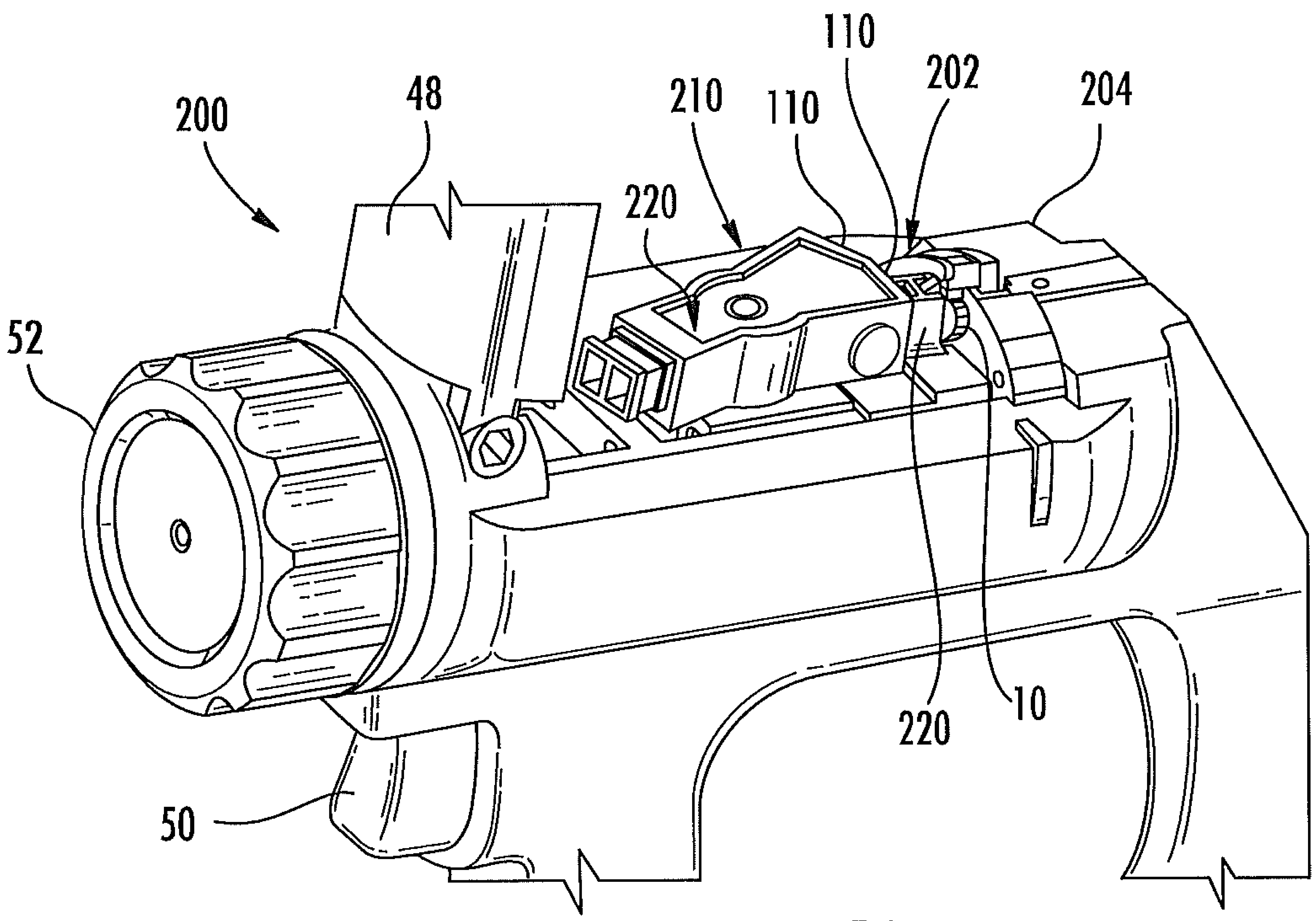
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FIG. 10

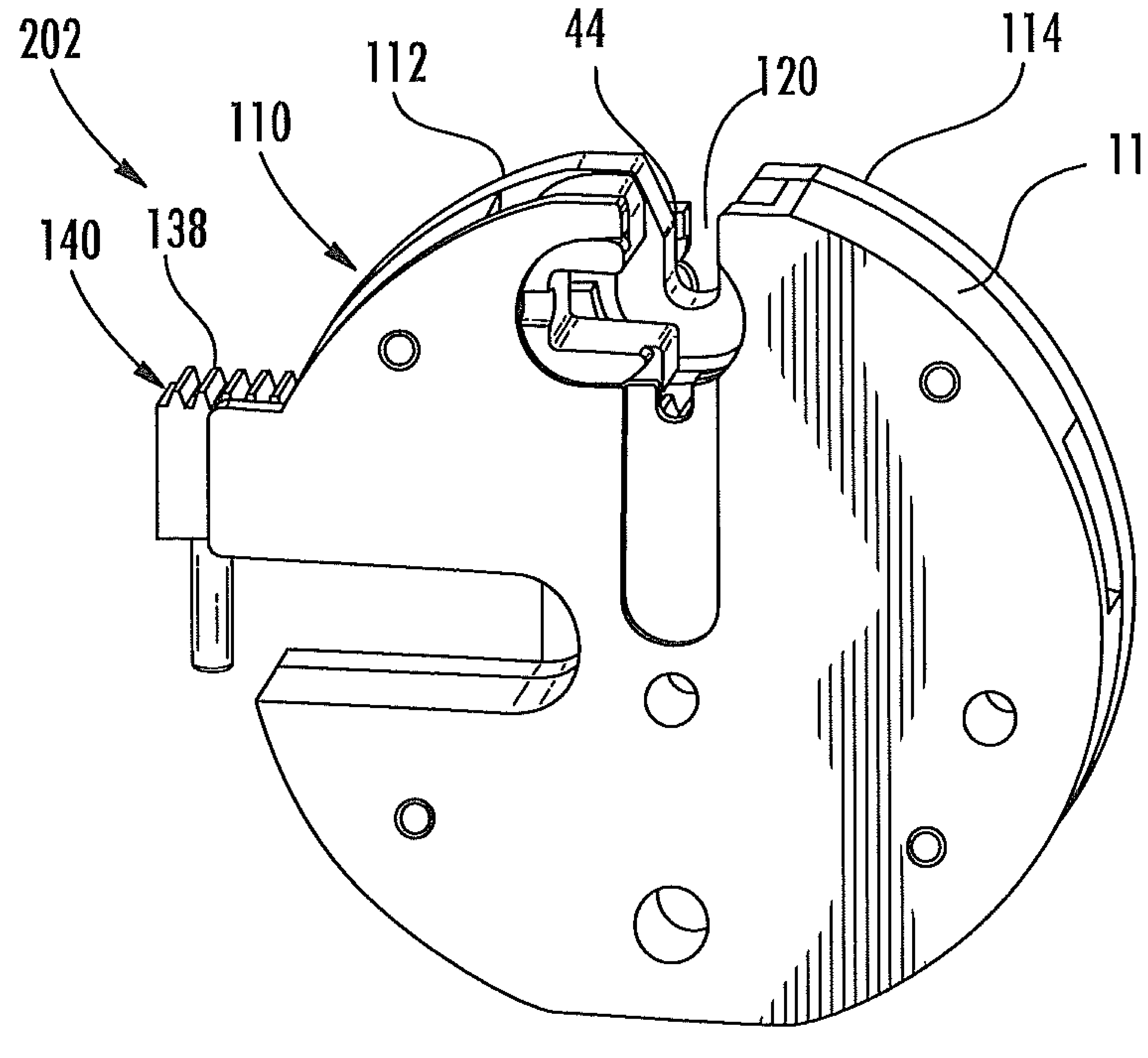
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FIG. 11

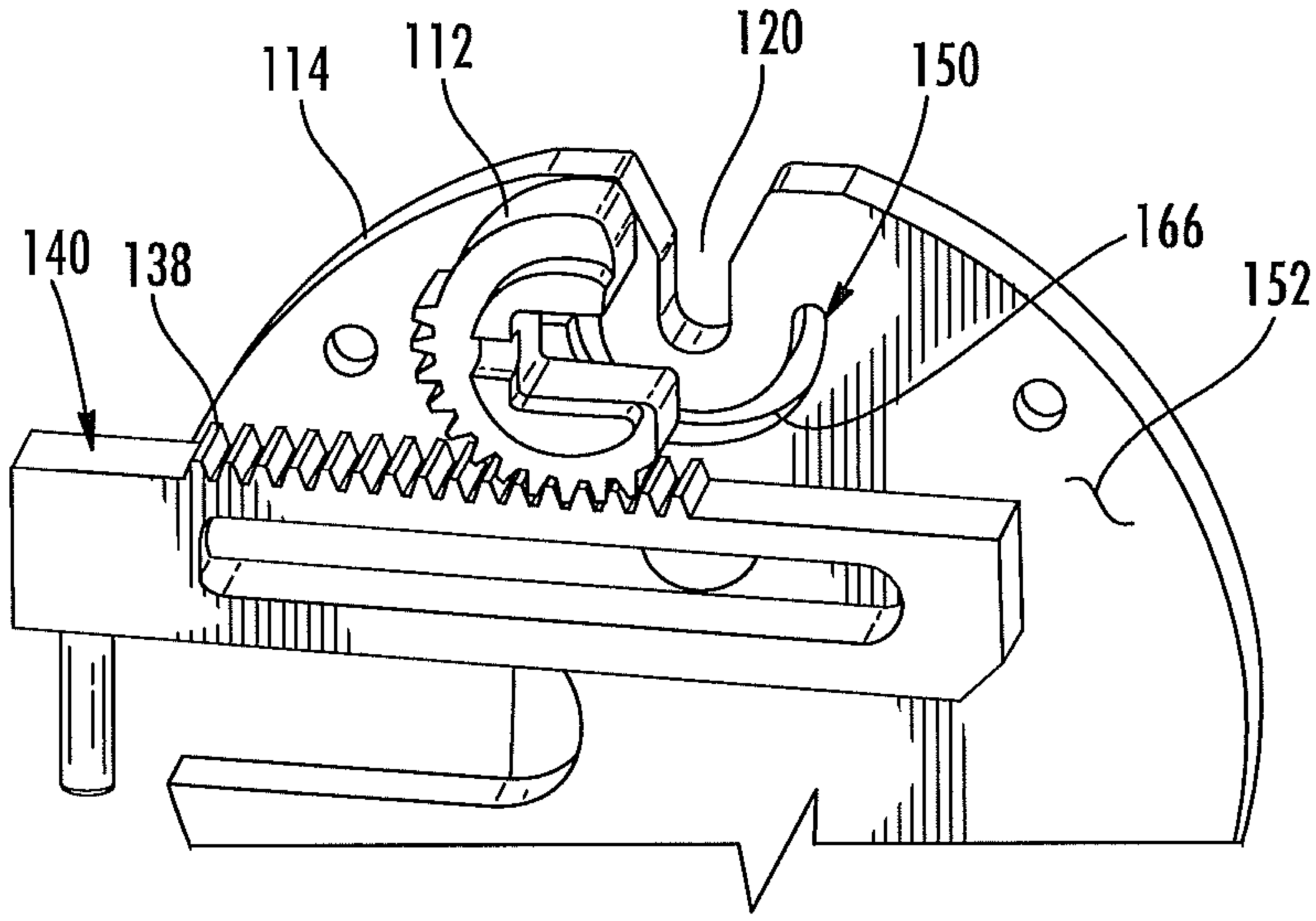

FIG. 12

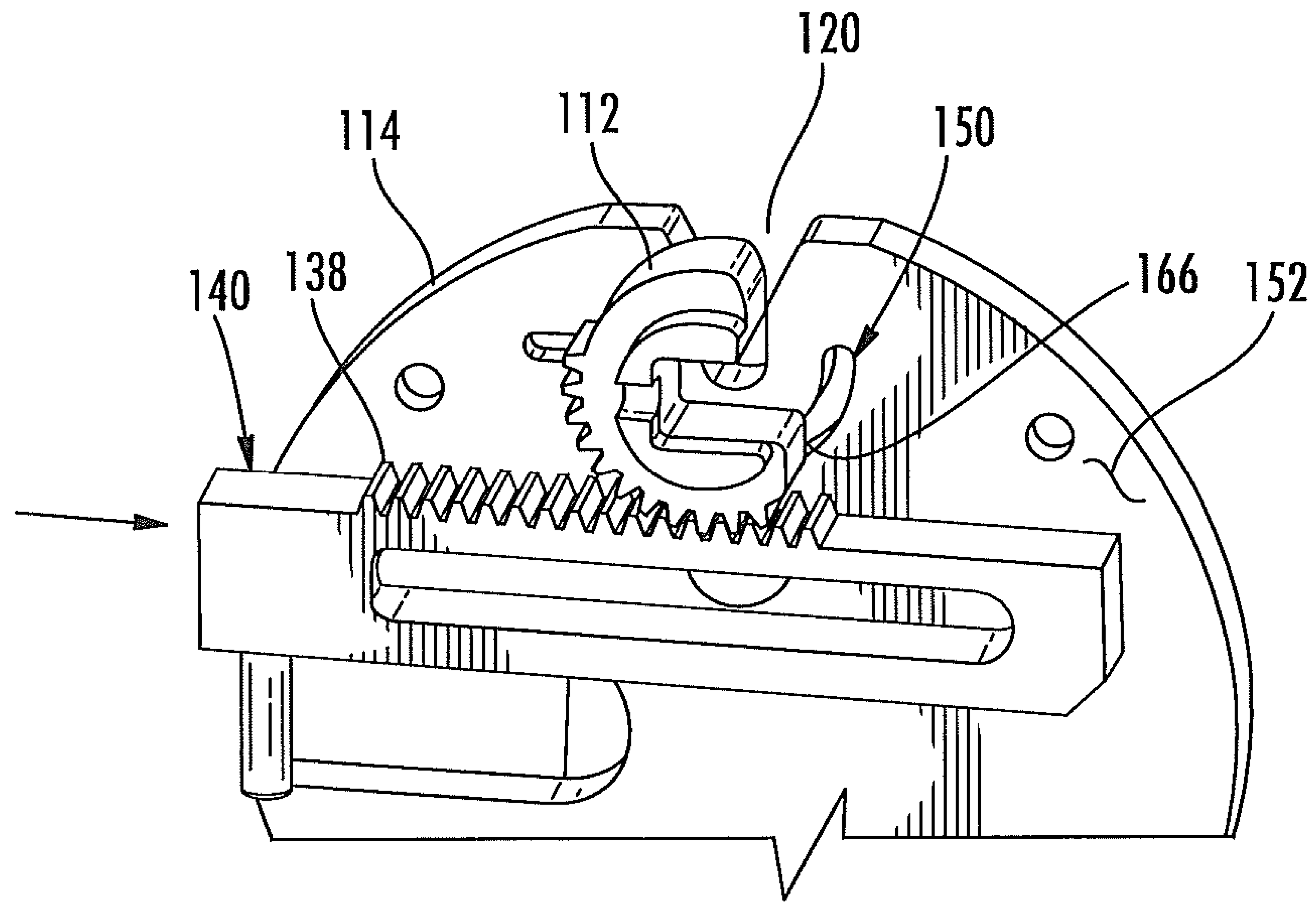

FIG. 13

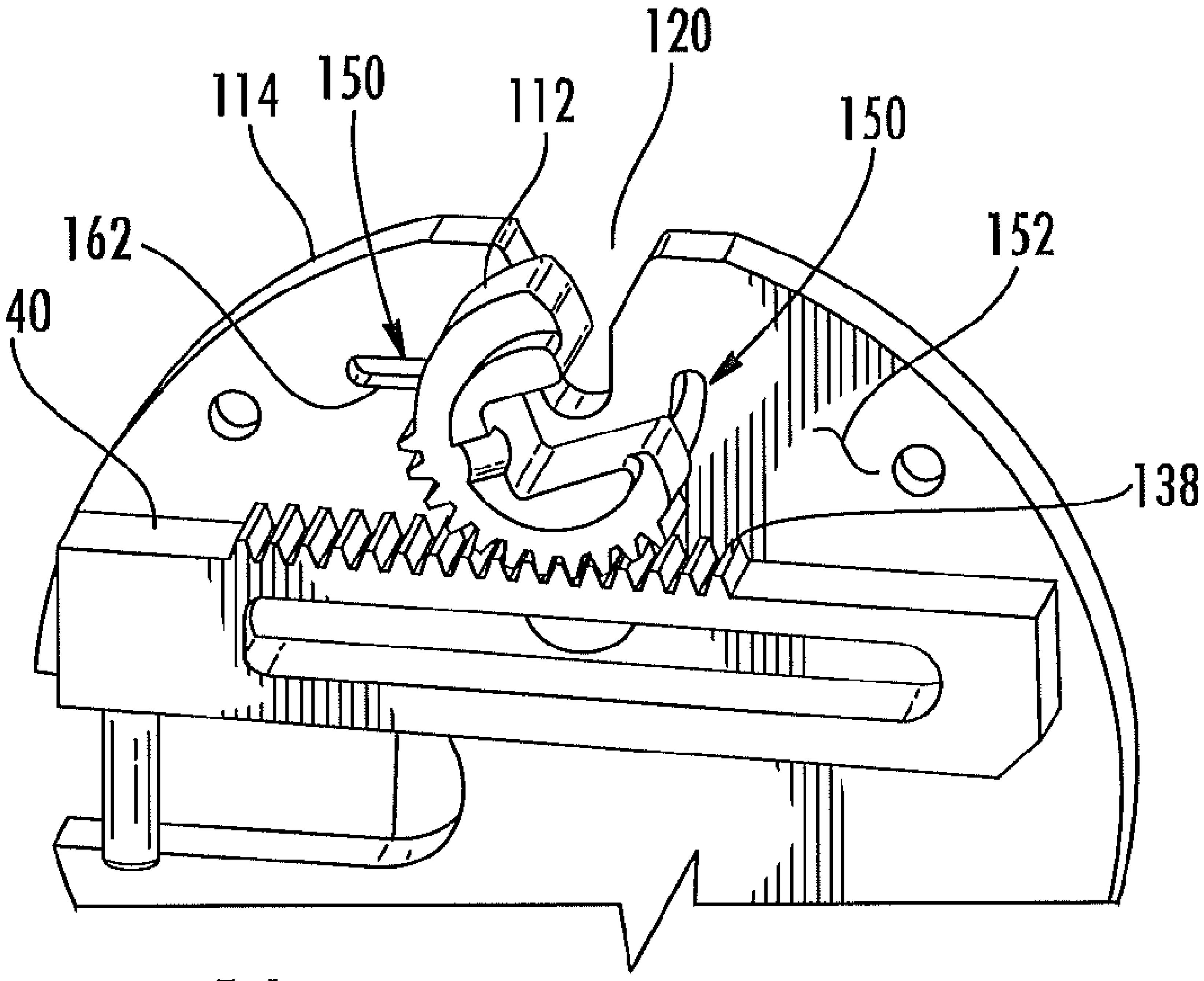

FIG. 14

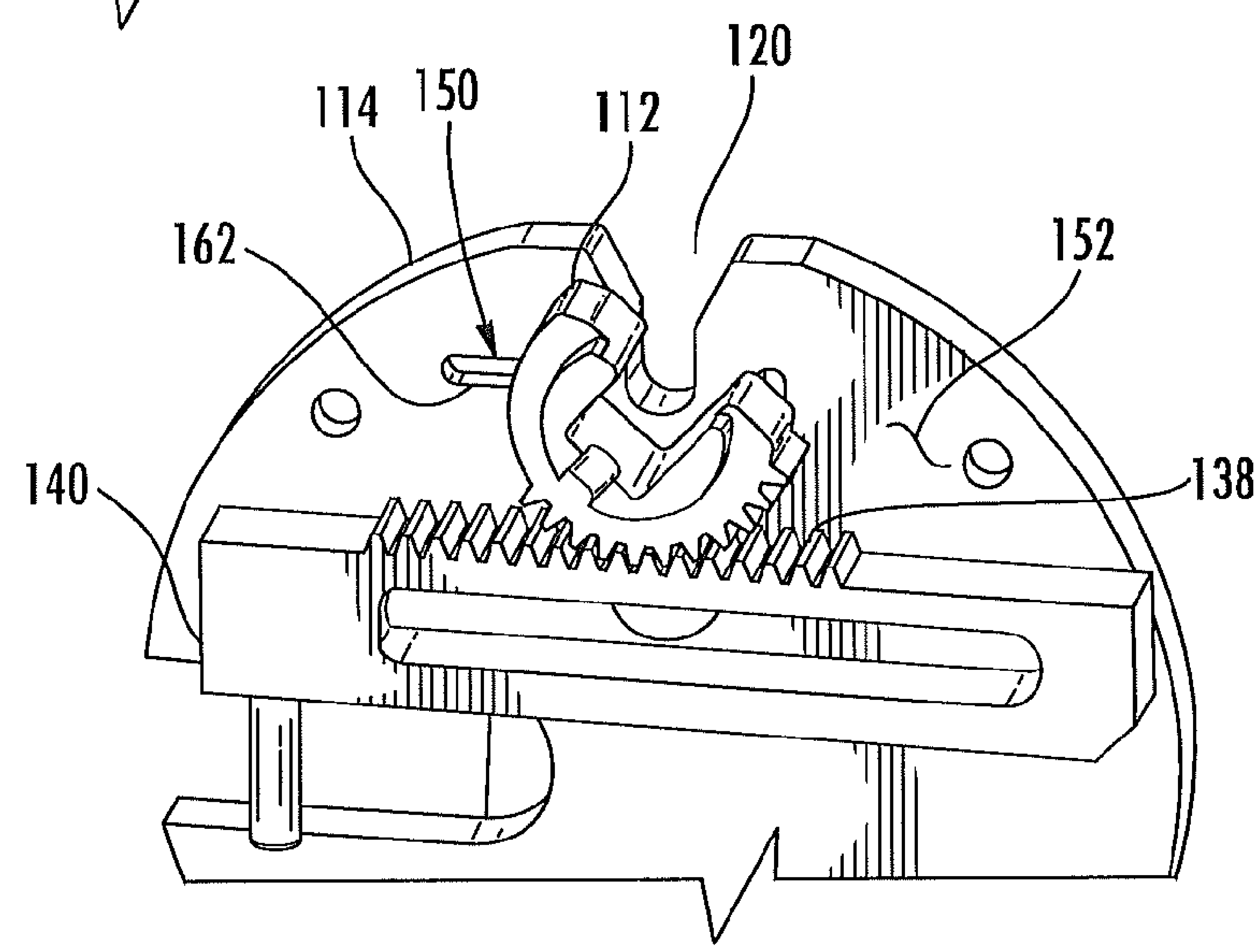

FIG. 15

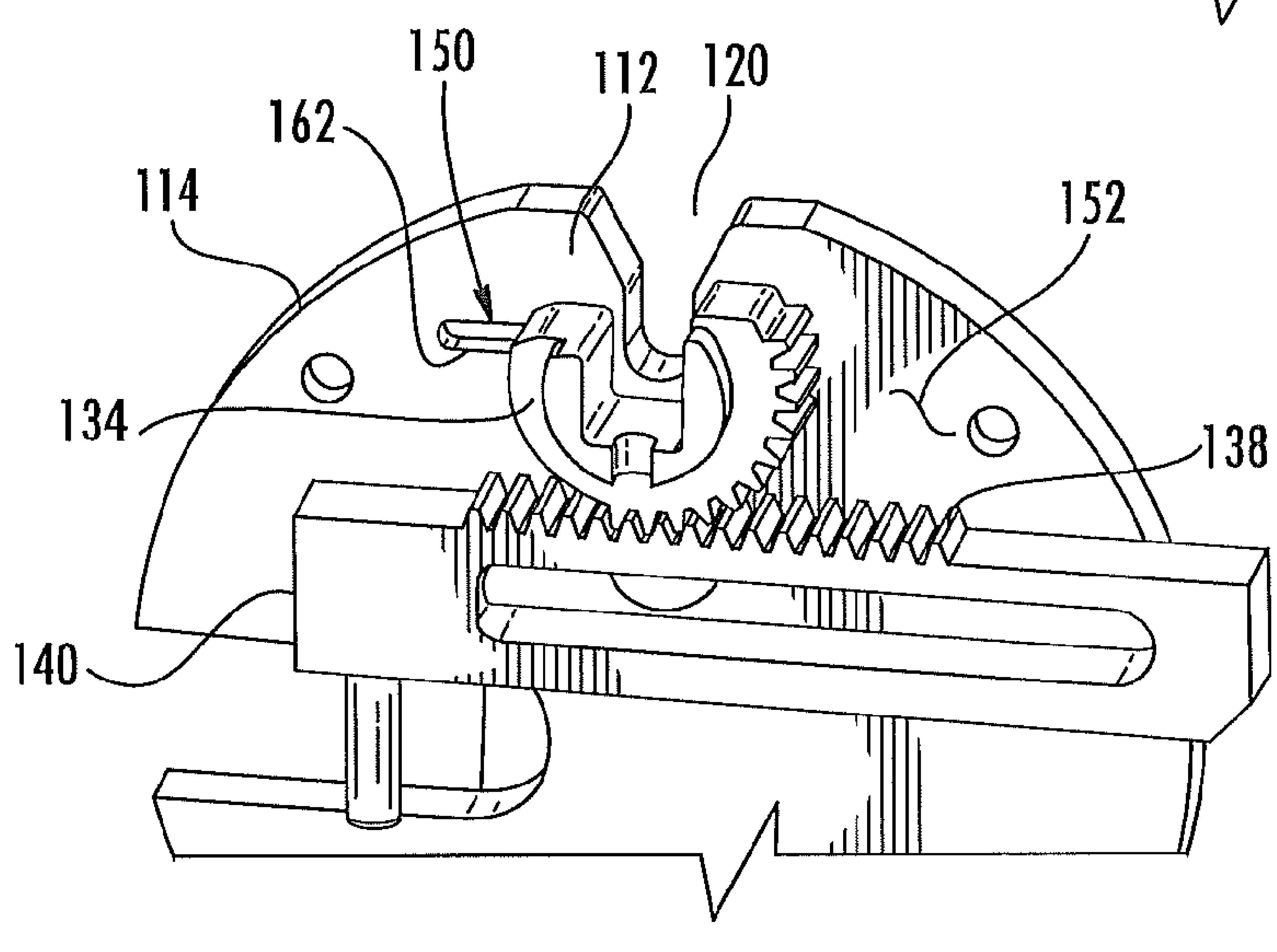

FIG. 16

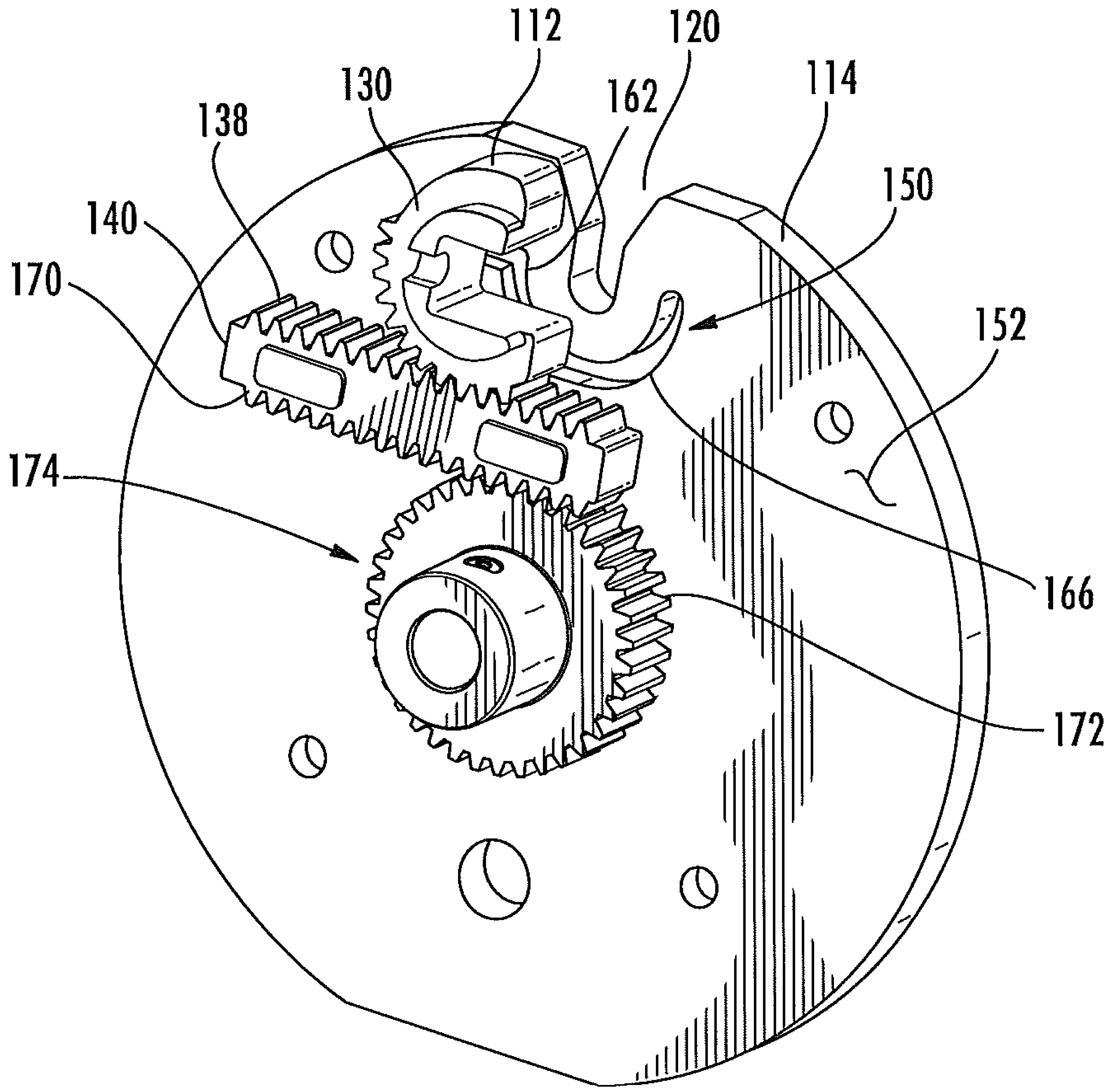

FIG. 17

FIBER OPTIC CONNECTOR INSTALLATION TOOL

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of priority under 35 U.S.C. §119 of U.S. Provisional Application Ser. Nos. 61/871,396 and 61/871,558, both of which were filed on Aug. 29, 2013, and both of whose content is relied upon and incorporated herein by reference in its entirety.

BACKGROUND

The disclosure relates generally to installation tools and methods for terminating one or more optical fibers with a fiber optic connector, and more particularly to such installation tools and methods having a camming member for actuating a portion of the fiber optic connector to secure the fiber optic connector to the one or more optical fibers.

Optical fibers are useful in a wide variety of applications, including the telecommunications industry for voice, video, and data transmission. Due at least in part to the extremely wide bandwidth and the low noise operation provided by optical fibers, the variety of applications in which optical fibers are being used is continuing to increase. For example, optical fibers no longer serve merely as a medium for long distance signal transmission, but are being increasingly routed directly to the home and, in some instances, directly to a desk or other work location.

In a system that uses optical fibers, there are typically many locations where one or more optical fibers need to be optically coupled to one or more other optical fibers. The optical coupling is often achieved by fusion splicing the optical fibers together or by terminating the optical fibers with fiber optic connectors. Fusion splicing has the advantage of providing low attenuation, but can make reconfiguring the system difficult, typically requires expensive tools to perform the operation, and involves additional hardware to protect the spliced area after the operation. Termination, on the other hand, provides the flexibility to reconfigure a system by allowing optical fibers to be quickly connected to and disconnected from other optical fibers or equipment.

One challenge associated with termination is making sure that the fiber optic connectors do not significantly attenuate, reflect, or otherwise alter the optical signals being transmitted. Performing termination in a factory setting ("factory termination") is one way to address this challenge. The availability of advanced equipment and a controlled environment allow connectors to be installed on the end portions of optical fibers in an efficient and reliable manner. In many instances, however, factory termination is not possible or practical. For example, the lengths of fiber optic cable needed for a system may not be known before installation. Terminating the cables in the field ("field termination") provides on-site flexibility both during initial installation and during any reconfiguring of the system, thereby optimizing cable management. Because field termination is more user-dependent, fiber optic connectors have been developed to facilitate the process and help control installation quality.

One example of such a development is the UNICAM® family of field-installable fiber optic connectors available from Corning Cable Systems LLC of Hickory, N.C. UNICAM® fiber optic connectors include a number of common features, such as a mechanical splice between a preterminated fiber stub ("stub optical fiber") and an optical fiber

from the field ("field optical fiber"), and are available in several different styles of connectors, such as ST, SC, and LC fiber optic connectors. FIGS. **1**B and **1**B illustrate an exemplary fiber optic connector **10** belonging to the UNICAM® family of fiber optic connectors. A brief overview of the fiber optic connector **10** will be provided for background purposes. It should be noted, however, that the apparatuses and methods disclosed herein may be applicable to other fiber optic connectors that are actuated in some manner to help establish a splice connection with one or more optical fibers.

As shown in FIGS. **1**A and **1**B, the fiber optic connector **10** includes a ferrule **12** received in a ferrule holder **16**, which in turn is received in a connector housing **19**. The ferrule **12** defines a lengthwise, longitudinal bore for receiving a stub optical fiber **14**. The stub optical fiber **14** may be sized such that one end extends outwardly beyond a rear end **13** of the ferrule **12**. The fiber optic connector **10** also includes a pair of opposed splice components **17**, **18** within the ferrule holder **16**, a cam member **20** received over a portion of the ferrule holder **16** that includes the splice components **17**, **18**, a spring retainer **22** fixed to the connector housing **19**, and a spring **21** for biasing the ferrule holder **16** forwardly relative to the spring retainer **22** and connector housing **19**. At least one of the splice components **17**, **18** defines a lengthwise, longitudinal groove for receiving and aligning the end portion of the stub optical fiber **14** and an end portion of a field optical fiber **15** upon which the fiber optic connector **10** is to be mounted. An index-matching material (e.g., index-matching gel) may be provided within this groove for reasons mentioned below.

To mount the fiber optic connector **10** on the field optical fiber **15**, the splice components **17**, **18** are positioned proximate the rear end **13** of the ferrule **12** such that the end portion of the stub optical fiber **14** extending rearwardly from the ferrule **12** is disposed within the groove defined by the splice components **17**, **18**. Thereafter, the end portion of the field optical fiber **15** can be inserted through a lead-in tube (not shown in FIGS. **1**A and **1**B) and into the groove defined by the splice components **17**, **18**. By advancing the field optical fiber **15** into the groove defined by the splice components **17**, **18**, the end portions of the stub optical fiber **14** and the field optical fiber **15** make physical contact and establish an optical connection or coupling between the field optical fiber **15** and the stub optical fiber **14**. The index-matching material (e.g., index-matching gel) provided within the groove surrounds this optical connection to help reduce losses in optical signals that are transmitted between the filed optical fiber **15** and stub optical fiber **14**.

The splice termination of the fiber optic connector **10** is completed as illustrated in FIG. **1**B by actuating the cam member **20**, which engages a keel portion of the lower splice component **18** to bias the splice components **17**, **18** together and thereby secure the end portions of the stub optical fiber **14** and the field optical fiber **15** within the groove defined by the splice components **17**, **18**. This step is typically completed using a specially-designed installation tool. The cable assembly may then be completed, for example, by strain relieving a buffer **25** of the field optical fiber **15** to the fiber optic connector **10** in a known manner.

FIGS. **2**-**4** illustrate an installation tool **30** that is an example of those offered by Corning Cable Systems for mounting the UNICAM® family of fiber optic connectors upon the end portion of a field optical fiber. Similar to the description above for the fiber optic connector **10**, a brief overview will be provided for background purposes with the understanding that the systems and methods disclosed later herein are applicable to other types of installation tools. Indeed, as will be apparent, the systems and methods disclosed later herein may be applicable to any installation tool for terminating one or more optical fibers with a fiber optic connector that requires actuation to securely position the one or more field optical fibers in the fiber optic connector.

The installation tool **30** includes a body or housing **32** having an actuation assembly **33** and cradle **36**. The cradle **36** is slidable along guide rails **38** inside the body **32** and normally biased toward the actuation assembly **33**, as shown in FIG. **3**. Prior to inserting a fiber optic connector into the installation tool, the cradle **36** is moved away from the actuation assembly **33**. This movement may be achieved by pressing a load button **40**, which is operably coupled to the cradle **36** through mechanical linkages (not shown) within the body **32**. With the load button **40** depressed (FIG. **4**), a user may place a fiber optic connector **10** into the space between the actuation assembly **33** and cradle **36**, and subsequently move a lead-in tube **26** of the fiber optic connector **10** axially through a camming member or wrench **34** of the actuation assembly **33** until the cam member **20** is seated in the camming member **34**. At this point, the lead-in tube **26** extends beyond crimp arms **44** that are positioned next to the actuation assembly **33**. Before inserting a field optical fiber **15** into the lead-in tube **26**, the load button **40** is released so that the cradle **36** moves back toward the actuation assembly **33** until the front portion of the fiber optic connector **10** is seated in the cradle **36**. A visual fault locator (VFL) assembly **46**, the purpose of which will be briefly described below, is also slid toward the fiber optic connector **10** before closing a lid or cover **48** of the installation tool **30** and completing the termination process.

The field optical fiber **15** is eventually inserted into the back of the lead-in tube **26** of the fiber optic connector **10** until it abuts the stub optical fiber **15** (FIGS. **1**A and **1**B) within the splice components **17**, **18**. A user then actuates the cam member **20**, for example by pressing a cam button **50** operably coupled to the camming member **34** by mechanical linkages (not shown), to bias the splice components **17**, **18** together and thereby secure the stub optical fiber **14** and field optical fiber **15** between the splice components **17**, **18**. At this point the VFL assembly **46** may be used to check the splice connection between the stub optical fiber **14** and field optical fiber **15**. The VFL assembly **46** includes an adapter **54**, a coupler **60**, a jumper (not shown; hidden within the installation tool **30**), and an optical power generator (also hidden from view) in the form of a Helium Neon (HeNe) gas laser. The operation of these components is not the focus of this disclosure. Thus, the Corning Cable Systems LLC system/method for verifying an acceptable splice termination, which is commonly referred to as the "Continuity Test System" (CTS), and the combined functionality of the gas laser and jumper, which are commonly referred to as a "Visual Fault Locator" (VFL), will not be further described herein. Reference can instead be made to U.S. Pat. No. 8,094,988, for example, to obtain a more complete understanding of how the installation tool **30** advantageously incorporates continuity testing. Once an acceptable splice termination is verified, the crimp arms **44** are actuated by rotating a crimp knob **52** to secure the lead-in tube **26** onto the field optical fiber **15**.

Pressing the cam button **50** to actuate the cam member **20** by means of the camming member **34** moves the camming member **34** from a closed configuration to an open configuration, as shown in FIGS. **5**A and **5**B. More specifically, the camming member **34** is a spur gear wrench that rotates about the termination axis defined by the stub optical fiber **14** and field optical fiber **15**. In a "start" position of the camming member **34** (FIG. **5**A), a closed portion of the camming member **34** faces up such that a user must load the fiber optic connector **10** into the camming member in an axial direction from a space between the camming member **34** and cradle **36**, as mentioned above. In a "finished" or actuated position of the camming member **34** (FIG. **5**B), an open portion of the camming member **34** faces up to allow for easy removal of the fiber optic connector **10** and field optical fiber **15**. After moving the VFL assembly **46** back away from the fiber optic connector **10** and then pressing the load button **40**, a user can simply grab the fiber optic connector **10** and lift straight up (i.e., away from the body **32**).

The movement of the camming member **34** between open and closed positions presents some challenges. In particular, loading the fiber optic connector **10** into the camming member **34** may not be intuitive because of the closed configuration a user sees. Moreover, even if the process for loading the fiber optic connector **10** is known or appreciated, positioning the fiber optic connector **10** between the camming member **34** and VFL assembly **46** and then subsequently moving the fiber optic connector **10** axially into the camming member **34** requires concentration because the opening of the camming member **34** is generally obstructed from view. The space constraints of the installation tool **30** also have the potential to present challenges. These and other factors have the potential to result in the fiber optic connector **10** being loaded into the installation incorrectly, which in turn has the potential to permanently damage the fiber optic connector **10** during the termination process. Therefore, a need exists for installation tools that address these challenges.

SUMMARY

This disclosure includes different embodiments of installation tools for terminating one or more field optical fibers with a fiber optic connector. The installation tools may be for use with fiber optic connectors that include a stub optical fiber extending from a ferrule into one or more splice components, which in turn are surrounded by a cam member. In some embodiments, such installation tools include a body configured to support the fiber optic connector with the stub optical fiber extending along a termination axis and a camming member having a connector slot configured to be received over the cam member of the fiber optic connector. The camming member has a first position relative to the body in which the connector slot is spaced from the termination axis. However, the camming member is configured to translate relative to the body to move the connector slot over the termination axis such that the termination axis extends through the connector slot. The camming member is also configured to rotate relative to the body to change the orientation of the connector slot.

In other embodiments of this disclosure, the installation tools include a guide member and camming member, which together may form an actuation assembly. The guide member has a slot extending in an axial direction and is configured to receive a portion of the fiber optic connector. The camming member is positioned next to the guide member and is movable between a first position spaced from the slot and a second position axially aligned with the slot. Additionally, the camming member is configured to engage and actuate the cam member of the fiber optic connector by moving from the first position to the second position when the fiber optic connector is received in the slot.

Another embodiment of this disclosure relates to an installation tool for terminating one or more field optical fibers with a fiber optic connector, with the fiber optic connector including a cam member configured to securely position the one or more field optical fibers in the fiber optic connector upon actuation. The installation tool includes a body configured to support the fiber optic connector and an actuation assembly configured to receive a portion of the fiber optic connector. The actuation assembly includes a camming member movable relative to the body so as to be configured to actuate the cam member of the fiber optic connector when the fiber optic connector is supported by the body. The actuation assembly is also configured so that the fiber optic connector can be loaded into the actuation assembly prior to actuation along a first path of movement and unloaded from the actuation assembly after actuation along the first path of movement. The first path of movement may be substantially perpendicular to a termination axis defined when the body of the installation tool supports the fiber optic connector.

A system for terminating one or more field optical fibers is also disclosed. The system includes a fiber optic connector and installation tool like any of those mentioned above.

Additional features and advantages will be set forth in the detailed description which follows, and in part will be readily apparent to those skilled in the art from the description or recognized by practicing the embodiments as described in the written description and claims hereof, as well as the appended drawings.

Indeed, it is to be understood that both the foregoing general description and the following detailed description are merely exemplary, and are intended to provide an overview or framework to understand the nature and character of the claims.

The accompanying drawings are included to provide a further understanding, and are incorporated in and constitute a part of this specification. The drawings illustrate one or more embodiment(s), and together with the description serve to explain principles and operation of the various embodiments. Persons skilled in the technical field of fiber optic connectors will appreciate how features and attributes associated with embodiments shown in one of the drawings may be applied to embodiments shown in others of the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A is a lengthwise cross-sectional view of one example of a field-installable mechanical splice connector being mounted on a field optical fiber by inserting the field optical fiber through a rear end of the mechanical splice connector;

FIG. **1**B is a lengthwise cross-sectional view similar to FIG. **1**A, but showing the field optical fiber mechanically spliced to a stub optical fiber within the mechanical splice connector by means of splice components that have been moved to an actuated position by a cam member;

FIG. **2** is a perspective of one example of an installation tool for terminating a field optical fiber with a fiber optic connector, such as the mechanical splice connector of FIGS. **1**A and **1**B, wherein the installation tool is shown in a closed configuration;

FIG. **3** is a perspective view of the installation tool of FIG. **2** in an open configuration prior to use;

FIG. **4** is a perspective view of the installation tool of FIG. **2** in an open configuration, wherein a fiber optic connector is shown being loaded into the installation tool;

FIGS. **5**A and **5**B are perspective views of a camming member of the installation tool in an initial/start position and a finished/actuated position;

FIG. **6** is a perspective view of one example of an installation tool for terminating a field optical fiber with a fiber optic connector, wherein the installation tool includes an actuation assembly according to one embodiment of this disclosure;

FIG. **7** is a perspective view of one embodiment of an actuation assembly according to this disclosure;

FIG. **8** is a perspective view of a camming member of the actuation assembly of FIG. **7**;

FIG. **9** is a perspective view of a portion of a guide member of the actuation assembly of FIG. **7**;

FIG. **10** is a perspective view of another example of an installation tool for terminating a field optical fiber with a fiber optic connector, wherein the installation tool includes an actuation assembly according to another embodiment of this disclosure;

FIG. **11** is a perspective view of the actuation assembly of FIG. **10**;

FIGS. **12-16** are perspective views sequentially illustrating movement of a camming member of the actuation assembly of FIG. **10** from a first position to a second position; and

FIG. **17** is a perspective view of a portion of an actuation assembly according to an alternative embodiment.

DETAILED DESCRIPTION

Various embodiments will be further clarified by the following examples, which relate to installation tools for terminating one or more optical fibers with a fiber optic connector. The fiber optic connector may include one or more short, preterminated optical fibers ("optical fiber stubs") to which one or more optical fibers from the field ("field optical fibers") are optically coupled. To this end, the examples described below may be used in connection with the fiber optic connector **10** (FIGS. **1**A and **1**B). Reference can be made to the background section above for a complete description of the fiber optic connector **10**, including how the cam member **20** is configured to the bias the splice components **17**, **18** together to secure the field optical fiber **15** relative to the optical fiber stub **14** and thereby establish a mechanical splice connection. However, as noted in the background section, the examples disclosed herein may also be applicable to installation tools for other fiber optic connectors that are actuated to establish/secure a splice connection, including fiber optic connectors involving splices done in a factory rather than in the field and/or fiber optic connectors involving multiple fibers instead of single fibers. Therefore, any references to the fiber optic connector **10** below are merely to facilitate discussion.

Similar considerations apply with respect to aspects of the installation tools not related to actuating such fiber optic connectors. Indeed, the disclosure below focuses on actuation assemblies and/or camming members that may be used in many different configurations and arrangements of installation tools. As shown in FIG. **6**, one embodiment may even be an installation tool **100** that is the same as the installation tool **30** (FIGS. **2-4**) but for the actuation assembly **33** being replaced with an actuation assembly **102** according to this disclosure.

With this in mind, FIG. **7** illustrates one embodiment of the actuation assembly **102** in isolation. The actuation assembly **102** includes a guide member **110** and a camming member **112**. In the embodiment shown, the guide member

110 includes opposed first and second walls **114**, **116** and an interior space **118** defined between the first and second walls **114**, **116**. The first and second walls **114**, **116** may be first and second plate-like members shaped to form the interior space **118** when bolted or otherwise secured together, for example. An axially-extending slot **120** is provided through an upper portion of the guide member **110** to accommodate insertion and removal of a fiber optic connector in a vertical direction. This ability to load and unload the fiber optic connector along the same path of movement (i.e., in a vertical direction) is also due to the camming member **112** being positioned within the interior space **118** of the actuation assembly **102** and interfacing with the guide manner **110** in a particular manner, as will be described in greater detail below.

In general, and with additional reference to FIGS. **8** and **9**, the camming member **112** in this embodiment is in the form of a spur gear wrench. Accordingly, the camming member **112** has a substantially circular configuration with teeth **130** formed on a peripheral surface **132** and a connector slot **134** extending radially inward from the peripheral surface **132**. The teeth **130** are configured to engage a rack gear **140**, which itself is configured to translate relative to the body **32** (FIG. **6**) of the installation tool **100** and guide member **110**. The connector slot **134** is configured to be received over the cam member **20** of the fiber optic connector **10** during operation of the installation tool **100**.

The camming member **112** also includes first and second projections **142**, **144** extending from a side surface **146** that confronts the first wall **114** of the guide member **110**. The first wall **114**, on the other hand, includes a channel **150** formed on a guide surface **152** that confronts the side surface **146** of the camming member **112** for receiving the first and second projections **142**, **144**. The rack gear **140** is configured to effect movement of the camming member **112**, and the channel **150** is configured to guide this movement. In particular, the channel **150** is configured to guide movement of the camming member **112** between a first position in which the camming member **112** is spaced from the slot **120** and a second position in which the camming member **112** is axially aligned with the slot **120**. Interaction between the first and second projections **142**, **144** and the channel **150** causes the camming member **112** to both translate and rotate when moving between the first and second positions. Again, the particular manner in which the camming member **112** interfaces with the guide member **110** will be described in greater detail below.

FIG. **10** illustrates an installation tool **200** based upon the same or similar principles as the installation tools **30** (FIGS. **2-4**) and **100** (FIG. **6**), but having a different shape/configuration of components. For example, the installation tool **200** includes a body **204**, an actuation assembly **202**, and a test system **210** for checking the spice connection that the installation tool **200** eventually establishes between a fiber optic connector **10** and field optical fiber. To this end, the test system **210** serves the same purpose as the VFL assembly **46** in the installation tools **30** and **100**. One difference is that the test system **210** includes an adapter **220** with different connector receiving areas for interfacing with different types of fiber optic connectors. The adapter **220** is movable relative to the body **204** to bring the appropriate connector receiving area **110** into alignment with the fiber optic connector **10** that has been loaded into the installation tool **200**. A connector holder **222** may be used to facilitate positioning the fiber optic connector **10** and interfacing with the adapter **220**. These and other aspects pertaining to the test system **210** are fully described in U.S. Provisional Patent Application No. 61/871,396, entitled "TEST SYSTEM FOR CHECKING A SPLICE CONNECTION BETWEEN A FIBER OPTIC CONNECTOR AND ONE OR MORE OPTICAL FIBERS" and filed on Aug. 29, 2013, which is herein incorporated by reference in its entirety.

More pertinent to this disclosure is the actuation assembly **202**, which is simply a different shape/configuration of the actuation assembly **102** (FIGS. **6-9**) such that the same reference numbers are used to refer to corresponding elements. The same reference numbers are also used to refer to elements on the installation tool **200** that correspond to elements on the installation tools **30** and **100** relating to the operation of the actuation assembly **202**. For example, with reference to FIGS. **10** and **11**, the body **204** is configured to support the fiber optic connector **10** so that the cam member **20** (FIGS. **1**A and **1**B) is received in the camming member **112** of the actuation assembly **202**. The lead-in tube **26** (hidden in FIG. **10**) of the fiber optic connector **10** extends from the actuation assembly **202** and through the pair of crimp arms **44**. After setting up the test system **210** in an appropriate manner based on the type of fiber optic connector being installed, a user inserts a field optical fiber **15** through the lead-in tube **26** and into the splice components **17**, **18** (FIGS. **1**A and **1**B) of the fiber optic connector **10** so as to abut or nearly abut the end of the stub optical fiber **14**. A cover **48** of the installation tool **200** is then closed over a workspace that includes the test system **210** and actuation assembly **202**. Next, the cam button **50** may be pressed to cause the camming member **112** to actuate the cam member **20** of the fiber optic connector **10**. The cam member **20** biases the splice components **17**, **18** together upon actuation to secure the end portions of the stub optical fiber **14** and field optical fiber **15**, thereby establishing the splice connection. The crimp arms **44** may then be actuated by rotating a crimp knob **52** or the like, at which point the cover **48** may be opened and the fiber optic connector **10** removed. Additional strain relieving to complete the cable assembly may then take place in a known manner.

The movement and positioning of the camming member **112** can be better understood with reference to FIGS. **12-16**, which sequentially illustrate the camming member **112** moving from the first position (i.e., initial/start position) to the second position (i.e., actuated/final position). In the first position (FIG. **12**), the camming member **112** is spaced from the slot **120** extending through the guide member **110**. The arrangement is such that an unobstructed path is defined by the slot **120**, allowing a user to move a fiber optic connector into the slot **120** from above (i.e., from a vertical direction). Stated differently, the connector slot **134** (FIG. **8**) of the camming member **112** is spaced from a termination axis extending through the slot **120** in the guide member **110**. The termination axis is the axis along which the stub optical fiber **14** extends when the fiber optic connector **10** is loaded in the installation tool **200** so as to be supported by the body **204**.

In the first position, the first and second projections **142**, **144** (FIG. **8**) of the camming member **112** are received in respective first and second straight portions **162**, **164** (FIG. **9**) of the channel **150** in the guide surface **152**. The first and second straight portions **162**, **164** are parallel and interconnected by a semi-circular portion **166** of the channel **150** that intersects the first and second straight portions **162**, **164**. More specifically, as shown in FIG. **9**, the channel **150** extends in a horizontal direction to define the first straight portion **162**, then downwardly in an arcuate manner to define a first half of the semi-circular portion **166**, and finally upwardly in an arcuate manner to define a second half of the arcuate portion **166**. The second straight portion **164** is substantially tangent to the semi-circular portion **166**, extending horizontally from where the first half of the semi-circular portion **166** transitions to the second half of the semi-circular portion **166**. The second straight portion **164** and second half of the semi-circular portion **166** may have a greater depth compared to the first straight portion **162** and first half of the semi-circular portion **166** for reasons mentioned below. In the first position, the first and second projections **142**, **144** of the camming member **112** are received in locations of the first and second straight portions **162**, **164** that are spaced from the semi-circular portion **166**. The first and second projections **142**, **144** may have different lengths to match the different depths of the first and second straight portions **162**, **164**.

Movement of the camming member **112** may be effected by the rack gear **140** translating relative to the camming member **112**. For example, the cam button **50** (FIG. **10**) may be pressed inwardly relative to the body **204** of the installation tool **200** to actuate the rack gear **140** directly or indirectly (e.g., via mechanical linkages). Because the teeth **130** of the camming member **112** are engaged with teeth **138** on the rack gear **140**, and because interaction between the first and second projections **142**, **144** and first and second straight portions **162**, **164** of the channel **150** constrain movement to a horizontal degree of freedom, the camming member **112** translates along with the rack gear **140**. The translation continues until the first projection **142** reaches the end of the first straight portion **162** and the second projection **144** reaches the transition between the first and second halves of the semi-circular portion **166**. At this point (FIG. **13**), the camming member **112** is positioned so that the termination axis extends through the connector slot **134** (FIG. **8**). Thus, when the fiber optic connector **10** has been loaded into the installation tool **200**, the connector slot **134** is received over the cam member **20** at this point.

Although further horizontal movement of the camming member **112** is constrained due to the shape of the channel **150** (e.g., the first and second straight portions **162**, **164** ending), a rotational degree of freedom is now provided by the semi-circular portion **166**. Continued translation of the rack gear **140** rotates the camming member **112**, including the connector slot **134**, about the termination axis. FIGS. **14-16**, illustrate various stages of this rotation. Ultimately the second projection **144** reaches an end of the semi-circular portion **166**, which prevents further rotation and represents the second position (actuated/final position) of the camming member **112**. By this time the connector slot **134** has rotated approximately 90 degrees, moving from a horizontal orientation to a vertical orientation. This movement actuates the cam member **20** when the fiber optic connector **10** has been loaded into the installation tool **200**.

As shown in FIG. **16**, the connector slot **134** faces up in the second position of the camming member **112**. As was the case when the camming member **112** was in the first position, the arrangement is such that an unobstructed path is defined by the slot **120** through the guide member **110**. Thus, a user can remove the fiber optic connector **10** from the actuation assembly **202** along the same path of movement (i.e., along a vertical direction) that was used to load the fiber optic connector **10** into the installation tool **200**.

In some embodiments, the rack gear **140** may be biased towards the first position and configured to be locked in the second position. Therefore, whenever a user does not have the cam button **50** pressed, the camming member **112** is either in or moved to the first position or retained in the second position. Thus, the first and second positions effectively represent the only positions of the camming member **112** when the actuation steps (to actuating the cam member **20**) are not actively being performed. In light of this, the unique configuration of the camming member **112**, and the particular manner of movement, the actuation assembly **202** effectively has an "always open" pathway for loading and unloading a fiber optic connector. A user can easily load and unload a fiber optic connector from above, with a clear view of the workspace. The likelihood of incorrectly loading a fiber optic connector is reduced, which in turn reduces the likelihood of an unsuccessful termination and/or damage to the fiber optic connector during the termination process.

Note that when the camming member **112** moves back to the first position after actuation, the different lengths of the first and second projections **142**, **144** help prevent binding/jamming. In particular, the second projection **144** may have a length greater than the depth of the first half of the semi-circular portion **166** and first straight portion **162**. Such an arrangement helps ensure that the second projection **144** only moves along the path defined by the second half of the semi-circular portion **166** and the second straight portion **164**, despite the first half of the semi-circular portion **166** intersecting the path.

In alternative embodiments, rather than the cam button **50** being used to move the rack gear **140**, installation tools according to this disclosure may include a knob or other rotatable actuator to move the rack gear **140**. FIG. **17** illustrates a portion of an actuation assembly **302** for such embodiments. As can be seen, the rack gear **140** may include teeth **170** on a bottom side for engaging teeth **172** of a spur gear or pinion **174**. The spur gear **174** is operably coupled to the rotatable knob/actuator (not shown) by one or more shafts or other mechanical linkages. Thus, when a user rotates the knob, the spur gear **174** rotates to move the rack gear **140**, which in turn moves the camming member **112** in the manner described above.

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Further embodiments, modifications, and variations within the scope of the claims below will be apparent to persons skilled in the art. For example, although the guide surface **152** (and channel **150**) in the embodiments discussed above are formed on the first wall **114** of the guide member **110**, in other embodiments the opposite wall of the guide member **110** (i.e., second wall **116**; see FIG. **7**) may define the guide surface **152** and channel **150**. Alternatively, in some embodiments both the first and second walls **114**, **116** may define guide surfaces having respective channels formed thereon for receiving projections on opposite sides of the camming member **112**.

Since modifications, combinations, sub-combinations, and variations of the disclosed embodiments may occur to persons skilled in the art, the invention should be construed to include everything within the scope of the appended claims and their equivalents.

What is claimed is:

1. An installation tool for terminating one or more field optical fibers with a fiber optic connector, wherein the fiber optic connector includes one or more stub optical fibers extending from a ferrule into one or more splice components that are surrounded by a cam member, the installation tool comprising:

a guide member having a slot extending in an axial direction and configured to receive a portion of the fiber optic connector; and

a camming member positioned next to the guide member, wherein the camming member is movable in a horizontal direction between a first position spaced from the slot and a second position axially aligned with the slot, and further wherein the camming member is configured to engage the cam member of the fiber optic connector by moving in the horizontal direction from the first position to the second position when the fiber optic connector is received in the slot and actuate the cam member by rotating after moving in the horizontal direction.

2. The installation tool of claim **1**, wherein the guide member includes a guide surface confronting the camming member and a channel formed on the guide surface, and further wherein at least a portion of the camming member is received in the channel on the guide surface, the channel being configured to guide movement of the camming member between the first and second positions.

3. The installation tool of claim **2**, wherein the camming member includes first and second projections received in the channel at spaced apart locations.

4. The installation tool of claim **1**, wherein the camming member includes a connector slot configured to receive the cam member of the fiber optic connector, wherein the connector slot has a horizontal orientation when the camming member is in the first position and a vertical orientation when the camming member is in the second position.

5. The installation tool of claim **1**, wherein the camming member comprises a spur gear wrench, the installation tool further comprising:

a rack gear engaged with the spur gear wrench, wherein the camming member is configured to move between the first and second positions as a result of being driven by the rack gear and interacting with the guide member.

6. The installation tool of claim **5**, further comprising:

a pinion gear engaged with the rack gear on an opposite side from the spur gear wrench.

7. The installation tool of claim **1**, wherein the guide member has opposed first and second walls and an interior space defined between the first and second walls, the camming member being positioned in the interior space of the guide member.

8. The installation tool of claim **1**, further comprising:

a body containing the camming member and guide member.

9. The installation tool of claim **8**, further comprising:

an actuator configured to be pressed inwardly or rotated relative to the body, the actuator being operably coupled to the camming member to move the camming member between the first and second positions.

10. An installation tool for terminating one or more field optical fibers with a fiber optic connector, wherein the fiber optic connector includes a stub optical fiber extending from a ferrule into one or more splice components surrounded by a cam member, the installation tool comprising:

a body configured to support the fiber optic connector with the stub optical fiber extending along a termination axis; and

a camming member having a connector slot configured to be received over the cam member of the fiber optic connector, wherein the camming member has a first position relative to the body in which the connector slot is spaced from the termination axis, the camming member being configured to translate relative to the body to move the connector slot over the termination axis such that the termination axis extends through the connector slot, the camming member also being configured to rotate relative to the body to change the orientation of the connector slot.

11. The installation tool of claim **10**, further comprising:

a guide member coupled to the body and interfacing with the camming member, wherein the guide member is configured to guide the translation and rotation of the camming member relative to the body.

12. The installation tool of claim **11**, wherein the guide member includes a guide surface confronting the camming member and a channel formed on the guide surface, and further wherein at least a portion of the camming member is received in the channel on the guide surface, the channel being configured to guide the translation and rotation of the camming member relative to the body.

13. The installation tool of claim **12**, wherein the channel includes first and second straight portions that are parallel and a semi-circular portion intersecting the first and second straight portions, and further wherein the camming member includes first and second projections received in the first and second straight portions, respectively, when the camming member is in the first position.

14. The installation tool of claim **10**, wherein the camming member is configured to rotate so as to change the orientation of the connector slot by about 90 degrees.

15. The installation tool of claim **14**, wherein the connector slot has a horizontal orientation when the camming member is in the first position and a vertical orientation when the camming member is in a second position.

16. A system for terminating one or more field optical fibers, comprising:

a fiber optic connector having a ferrule, two or more splice components proximate a rear end of the ferrule, a camming member surrounding the two or more splice components, and a stub optical fiber extending from the ferrule into the two or more splice components, the cam member being configured to bias the two or more splice components together upon actuation; and

an installation tool comprising:

a body configured to support the fiber optic connector with the stub optical fiber extending along a termination axis; and

an actuation assembly configured to receive a portion of the fiber optic connector, the actuation assembly including a camming member movable relative to the body so as to be configured to actuate the cam member of the fiber optic connector when the fiber optic connector is supported by the body, the camming member having a connector slot configured to be received over the cam member of the fiber optic connector;

wherein the camming member has a first position relative to the body in which the connector slot is spaced from the termination axis, the camming member being configured to translate in a horizontal direction relative to the body to move the connector slot over the termination axis such that the termination axis extends through the connector slot, the camming member also being configured to rotate relative to the body to change the orientation of the connector slot.

17. The system of claim **16**, wherein the actuation assembly comprises:

a guide member having a slot extending in an axial direction and configured to receive a portion of the fiber optic connector;

wherein the guide member is positioned next to the camming member and configured to guide movement of the camming member.

18. An installation tool for terminating one or more field optical fibers with a fiber optic connector, wherein the fiber optic connector includes one or more stub optical fibers extending from a ferrule into one or more splice components that are surrounded by a cam member, the installation tool comprising:

a guide member having a slot extending in an axial direction and configured to receive a portion of the fiber optic connector; and

a camming member positioned next to the guide member; wherein:

the camming member is movable between a first position spaced from the slot and a second position axially aligned with the slot;

the camming member is configured to engage and actuate the cam member of the fiber optic connector by moving from the first position to the second position when the fiber optic connector is received in the slot;

the guide member includes a guide surface confronting the camming member and a channel formed on the guide surface;

the channel includes first and second straight portions that are parallel and a semi-circular portion intersecting the first and second straight portions;

the camming member includes first and second projections received in the respective first and second straight portions of the guide surface at spaced apart locations when the camming member is in the first position; and

the channel is configured to guide movement of the camming member between the first and second positions.

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